FEBRUARY, 1984

THE INDIAN FORESTER

Eucalyptus Special- 3

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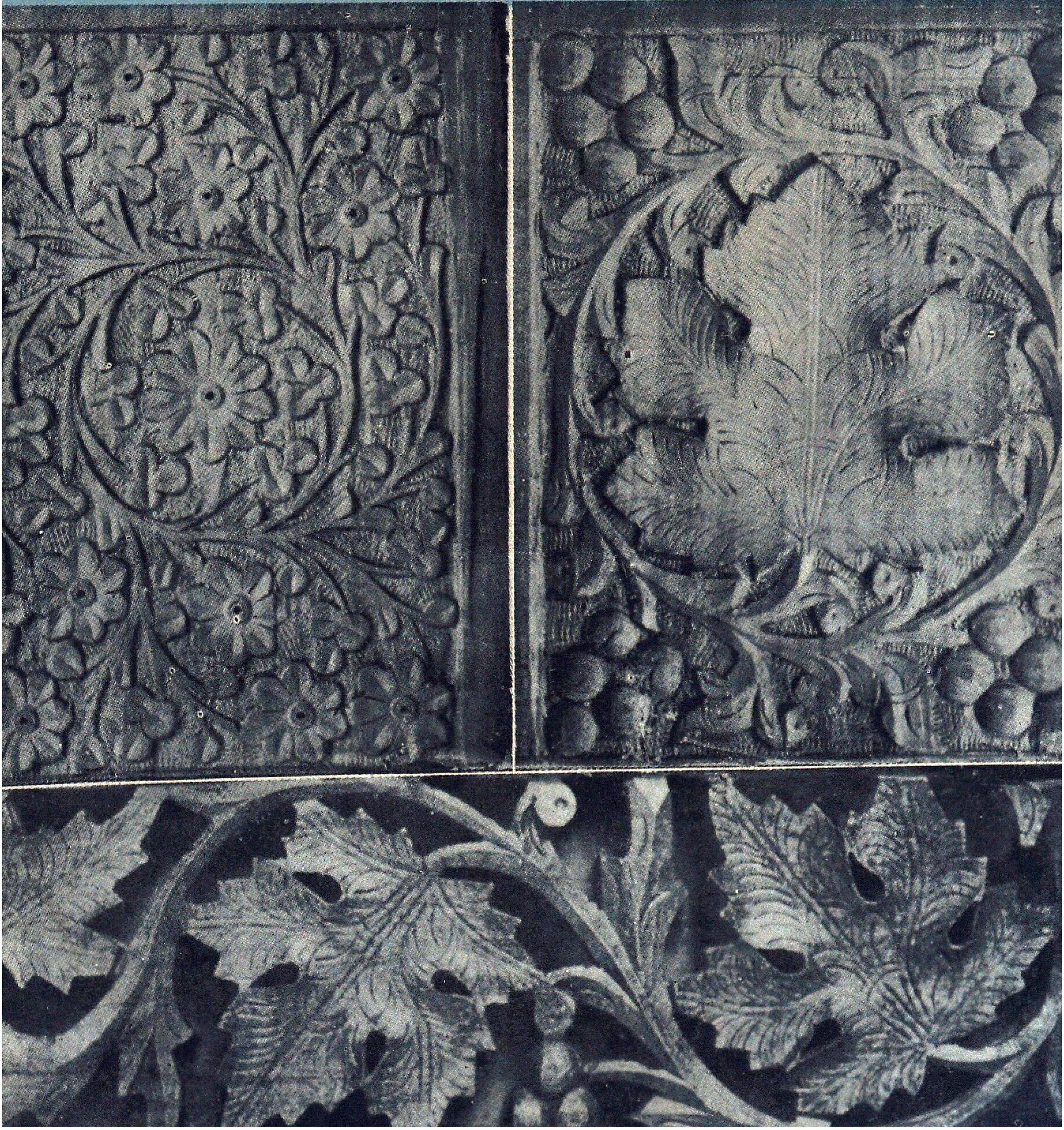

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INDIAN FORESTER

(A Monthly Journal of Forestry and Forestry Research)

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125/84

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THE INDIAN FORESTER

Vol. 110 February, 1984 No. 2

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FRONT COVER

SHOWING HAND CARVING PATTERNS ON *EUCALYPTUS HYBRID*

Photo – V.P. Jaitly

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HONEY COMB CARVED PATTERN ON *EUCALYPTUS HYBRID* USING FRET SAW.

Photo – V P. Jaitly

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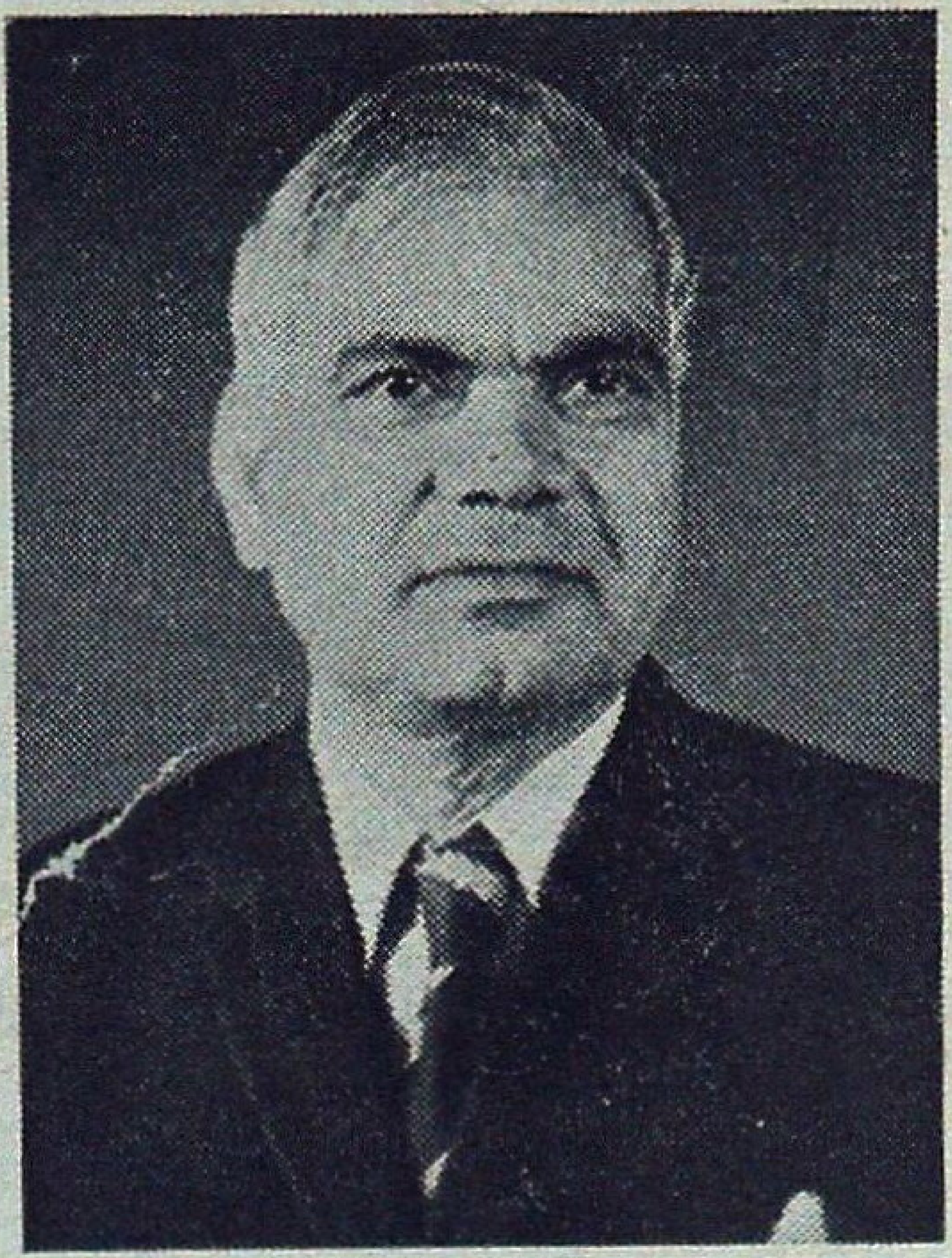
VOLUME 110 NUMBER 2

THE INDIAN FORESTER

FEBRUARY, 1984

EDITORIAL



With this issue we bid farewell to Shri K.M. Tiwari, I.F.S., our Vice-Chairman of the Board of Management and President of the Central Editorial Board, who relinquished charge of the post of the President, Forest Research Institute and Colleges, Dehra Dun on 31st January, 1984, on superannuation from service.

Shri K M. Tiwari needs no introduction to our readers. His pioneering work in the field of Social Forestry is well known. He laid the foundation of the Social Forestry Project in Uttar Pradesh and through this programme has sought to serve the cause of the rural poor which is so close to his heart. The *Indian Forester* under the Vice-Chairmanship of Shri Tiwari acquired a greater strength as a professional Journal, providing readers with up-to-date information on new technology in forestry. As the President, F.R I. and Colleges, Dehra Dun, he made important contributions to forestry including the writing of three books on Social Forestry.

He was unstinting in his appreciation of good work and his staff worked for him wholeheartedly and with confidence. For his pioneering and outstanding contribution to Indian Forestry, the Government of India awarded him 'Padma Shri' on the Republic Day 1984 We sincerely thank him for taking a keen interest in the welfare of the *Indian Forester* and wish him a long and happy life.

* * *

The *Eucalyptus* Special Issue III of the *Indian Forester* is also devoted to some important aspects of *Eucalyptus* cultivation and research in India.

* * *

The cover photo of this issue shows the wood of *Eucalyptus hybrid* has been used for carving at Saharanpur in U.P. This is the first cover photograph printed on carving in the *Indian Forester*. Some research was very recently initiated in Wood Working Saw Milling and Finishing Branch of the F.R.I. and Colleges, Dehra Dun for evaluating the suitability of different *Eucalyptus* species grown in our country for carving. The preliminary observations indicated that carving on *Eucalyptus* can be done as easily as on *Sissoo*, the conventional wood used for this purpose. Visual appearance of carving designs is more attractive than the grain pattern as seen in most of the other timbers. After polishing, high gloss slightly more than teak was also developed in *Eucalyptus*. Further work on carving properties in *Eucalyptus* is in progress.

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The relative merit of this genus over others has attracted the attention of researchers throughout the world. The lead article of this issue (page 91) throws light on some research priorities for *Eucalyptus*. Two articles in this issue are devoted to the economics of raising *Eucalyptus* plantation in the forest and agro-forestry systems. Similarly two articles are devoted to various aspects of biomass production from *Eucalyptus* trees.

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On page 117 the scientists of the Wood Seasoning Branch, F.R.I. and Colleges, Dehra Dun write about the new seasoning schedules for seasoning of *Eucalyptus* planks of 25 mm thickness. Further work on the seasoning of *Eucalyptus* of bigger cross sections is under study for utilisation as door and window frames etc.

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We hope that the three special issues have been useful to our readers and have brought into light hitherto unknown facts about the cultivation, management and utilisation of this bountiful gift of nature—the *Eucalyptus* tree.

—Hony. Editor

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—Hony. Editor

EUCALYPTUS IN INDIA – ITS STATUS AND RESEARCH NEEDS

C.L. BHATIA, I.F.S.
Inspector General of Forests

Eucalyptus was first introduced in India in the regime of Tippu Sultan from 1782 to 1802 at Nandi Hills, Bangalore and Sultanpet area in the Deccan. The recorded evidence of introduction from Australia to Nilgiris in the South of India have been shown by Captain Dunn and Capt. Cotton in 1843 when this species was planted to meet the firewood needs of the locality. However, regular plantation activity started in 1856 and the oldest plantation of *E. globulus* is still evident in the Nilgiris dating back to 1863. Large scale trials were taken up in 1951 in Assam, M.P., Bihar, Kerala, Maharastra and Uttar Pradesh.

E. tereticornis (Nandi provenance also known as *E hybrid* Mysore gum) proved superior in its edaphological adaptation out of a trial of 170 species/varieties/provenances tried in the country. This provenance could flourish from coastal areas to 2000 metres altitude: tropical to warm temperate climes and a rainfall range of 400 to 4000 mm. The species which have received countrywide acceptance are *E. tereticornis*, *E. camaldulensis*, *E grandis*, *E. citriodora* and *E. globulus*.

Eucalyptus is an ever green with wide ranging usefulness available for exploitation. The plant morphology suits multifarious requirement of new forestry practices like agri-silviculture, farm forestry, tree farming, industrial plantations, and such like practices. The wood can be used as construction timber, furniture, pulpwood, fuelwood and also for uses such as in making hardboard and particleboards. Leaves grow sparsely and cast low shadow and at different stages of growth yield oils of great variety of uses This tree can be used to plant at roadside, canal side, railway track and urban parks as well as wind breaks and shelterbelts. This tree forms a lucrative mix in the traditional agricultural systems and ensures attractive economic returns.

The relative merit of this genus over others has attracted the attention of researchers throughout the world. Many aspects of the performance of this species have been reported from F.R.I. in India, as well as elsewhere. A good deal of data are available with regard to species and site relationship for taking up major plantations in India Several recent publications give thorough insight on different aspects Several extension series on this species, including a country Report "1977" have been published from the F.R I. of which special mention may be made of the U.P. Forest Bulletin No : 43 pm "Eucalyptus for Farming" published in 1983.

Silvicultural perfection of traditional or exotic species is indispensible to a successful plantation effort Forest Research Institute and State Forest Departments in India have achieved reasonable expertise in the silviculture of *Eucalyptus*. Naked root planting suffers from a high mortality rate. Polybag planting of 4–6 months old plants is gradually overtaking it in many States, since it helps better initial growth and survival The plant grows well on varied sites but excellent growth requires well drained deep fertile soils Heavy soils and the once carrying high soluble salt content and an indurated pan at various depths are not suitable. Except in a few species of *Eucalyptus*, this genus does not tolerate waterlogging or extended periods of inundation and dryness. In many salt affected sites, multinutrient deficiency has occured It does not stand the rigours of unfavourable sites like semi-arid and arid lands and refractory areas unlike species such as *Dalbergia*. It requires certain minimum conditions for successful growth. Espacement varies from site to site and different states have their own espacement optimum (spacing range from 1.8 × 1.8 m to 3.0 × 3.0 m). Plants growing closer than 1.5 metre, do not give economically favourable yields. Spacing varies with object of planting and for a crop of 5 to 6 years rotation (for pulp or fuel) a spacing of 1.5 × 1.5 m is preferable.

Hybridization has been found to be an effective breeding method for tree improvement at Forest Research Institute. *E. tereticornis* and *E. camaldulensis* have been hybridized to produce FRI-4 and FRI-5 hybrids with definite improvement in height and diameter growth. *E. citriodora* and *E. torelliana* have also been crossed similarly Nuclear techniques like radiation induced mutation have been tried and the work is in progress at Forest Research Institute

Eucalyptus tereticornis, *E. camaldulensis* and *E. grandis* have done well and are widely accepted for raising commercial plantations. It is necessary to conduct extensive provenance trials of the same species from authentic seeds from areas of natural occurence to select the superior genetic material within the species Forest Research Institute as also the State Forest Departments have already initiated research programmes for conducting species-cum-provenance trials Seeds of various provenances of *E. tereticornis*, *E. grandis*, *E. camaldulensis*, *E. microtheca* and *E. urophylla* were obtained from CSIRO, Australia as part of International provenance programme. Broad zones in which these species can perform well were identified and seeds were sent accordingly.

Soil moisture distribution under *Eucalyptus* has been compared with other fast growing species. *Eucalyptus* takes up soil moisture from greater depths than pine and the soil does not suffer from critical stress in Doon Valley conditions. The soil fertility improvement through this species has been evident from the fact that compared to Sal the return of humus to the soil is of better quality, though quantitatively Sal returns more humus to the soil. Impact of raising a monoculture of *Eucalyptus* on soil in Doon Valley proved more effective in improving soil fertility than Sal monoculture. *Eucalyptus* improved both physical and chemical conditions of the soil. Soil conditions under natural Sal were richer compared to both monocultures.

Regarding the Soil moisture relations vis-a-vis growth of *Eucalyptus*, recent experiments done at F.R.I. and its Regional Research Stations have indicated that higher uptake of soil water has been more than compensated by high dry matter production which has made this species, in fact more efficient dry matter accumulator than others. Experiments in the Nilgiris have shown no adverse effect of raising this species on the catchment water yields The interception loss has always been reckoned as loss of that amount of water to the soil, hence it is inversely related to the rainfall reaching the ground *Eucalyptus* allows 2 to 3 times more rain reaching the ground than other species like Sal, Chir, Khair, Teak and *Alstonia scholaris*.

The propagation of *Eucalyptus* offers a good scope of multiplication through the use of suitable clones and seeds. The massive seed production by this species render propagation through seedlings a wide spread propagation feasibility. Organic productivity and nutrient cycling studies have been done at F.R.I. and the quantum of nutrients return to the soil have been assessed.

Utilization

Some of the contributing reasons for a wide acceptance of this species in the tropics and subtropics are the varied uses that this species can be put to for meeting supply deficits of many forest products. Eucalyptus has been used for timber, poles, pulp, fuel and for chemical products like essential oils and oxalic acid. The heavy green wood produced by this species weighs nearly a tonne per cubic meter and looses nearly a third of its weight on air drying. The air dried wood burns with a calorific yield of 4800 to 4000 K-Cal per kilogram of wood. Thus short coppice rotations can provide voluminous fuelwood of high calorific value which can still be improved when turned into charcoal with 7900 K-Cal yield per kilogram of charcoal. *Eucalyptus* pulp is of short fibre variety and has to be blended with a long fibre material to make most grades of paper as shown by the test runs at F.R.I.

The essential oils extracted from this species are cineole rich (63.2 to 72.3 percent) and show a favourable potential for import substitution for pharmaceutical industry in India. This species can be exploited at various rotations depending upon the end use. The bark yields therefore vary and the trees when exploited young yield substantial tanning from bark to give oxalic acid (40 to 45 percent of oven dry bark) which can be an attractive economic activity.

Surface cracking and splitting, warping and collapse are common seasoning defects since this species is a refractory timber to air or kiln seasoning. These defects can be reduced considerably through chemical seasoning and air drying before kiln seasoning. *E. hybrid* seasons well when sawn radially compared to tangential sawing.

Eucalyptus has been evaluated for particle and fibre boards and the tests at F.R.I. proved *E. hybrid* and *E. grandis* can be used without loss of quality though not without treatments. The blended *Eucalyptus* bark hard boards have also been tested. The WIMCO tests

on *Eucalyptus* as match wood material for splints do not go in favour of this species compared to *Bombax* and Poplars. To improve the splint properties some chemical treatments have also been suggested.

The wood has also been tested for panelling. Good quality veneers could not be obtained from *E. hybrid* because of resin pockets. However, this property varied from locality to locality and the same species at other locations gave better veneers. The bonding of *Eucalyptus* with P.F. and U.F. resin adhesives, the most vital property for plywood making is not very acceptable without modifying the resin through vetting agents and plasticizers. *Eucalyptus* poles have also been tested and they can be used effectively after treatment with preservative. The wood working qualities of this species are moderate. The wood lends to conventional polish and finishing methods easily.

Research priorities

The merit of *Eucalyptus* lies in its exploitability to cater to several human needs. Careful researches into various aspects of *Eucalyptus* forestry and *Eucalyptus* based industries need to be done more intensively than ever befoie to enable full use and at the same time prepare one for tackling any likely unfavourable effects especially due to monoculture. Eucalyptus Research Centre, Hyderabad under FRI & Colleges, Dehra Dun is already carrying out research studies on this genus. Some research priorities have been outlined for those engaged in such activities.

1. A thorough research is needed to determine the most suitable sites for different species for fuller genetic expression. Most definitely all sites are not suitable to all species.

2. Trials are necessary to determine the soil moisture and nutrient requirements to provide most definative answer to the prevailing controversy in the public mind.

3. Locality and site specific recommendations may be framed on the basis of findings.

4. Suitability of *Eucalyptus* for afforestation of difficult sites, wastelands, salt affected areas etc., must be tested thoroughly.

5. The tree improvement through genetics and plant breeding techniques should be intensified and recent techniques like tissue culture etc. should be employed without loss of time. Genetically superior material is always preferable, for it gives much better performance in the course of time. Seed orchards should be developed to help the breeding programme and maintenance of germ plasm stock for future needs.

6. Long term experimentation to study different aspects of monoculture of this species should be initiated at Institutions like F.R.I.

7. *Eucalyptus* as a mixed crop with tree legumes should be tested.

8. There is need to determine the impact of raising *Eucalyptus* on depletion pattern of soil fertility vis-a-vis profitability in an agroforestry system.

9. Much more extensive work is needed for working out optimum spacing for various commercial and other end uses.

10. Extensive work is required to be done for testing different species of *Eucalyptus* from organic productivity point of view.

11. Careful work is needed to be done on the effect of *Eucalyptus* on cropping pattern of important agricultural areas and pattern of choice of crops by the farmer.

12. Market research should be initiated for regulating the trends for maintenance of prices.

13. Due to the endless number of uses of this species, the research on the commercially exploitable properties of the wood should be intensified

14. Due to high level of genetic diversity the taxonomical research both at macro and micro level should be intensified.

15. Suitable species should be identified for afforestation and reforestation of all kinds of waste-lands and degraded areas in the country.

16. Very few reports are available on the effects of raising *Eucalyptus* on soil biology and biochemistry, including symbiotic, nitrogen fixation, mycorrhyzal behaviour. Research should be initiated in this area.

17. *Eucalyptus* plantations have been grown as a monoculture and not much information is available on the short and long term effects that it generates. The quantititave and qualitative changes that occur due to such monoculture can be easily anticipated for incidence of diseases and pestilence. The plant protection aspects, therefore, form an extremely important criterion for research and continuous surveillance and systematic monitoring is needed to keep plantations free from pathogens and insects

During the recent National Seminar on Eucalypts held at the Kerala Forest Research Institute, Peechi, the following recommodations were made with respect to Eucalypts planting in India. They are of much relevance in the current environment and should be taken into consideration in the future programmes.

1. Realizing the importance of maintaining the ecosystem, ecologically sensitive forest areas should not be planted with eucalypts and an all out effort should be made to regenerate such areas with indigenous species.

2. Realizing the growing demand and daily needs of the people/rural masses for firewood, poles and small-size timber, planting of eucalypts should be continued in suitable areas so that the gap between the demand and supply is bridged as early as possible

3. In view of the multipurpose use of eucalypts for housing and other purposes, marginal trees in the plantations of eucalypts be allowed to grow to large sizes to provide timber.

4. As there is further need for study with regard to the effect of the different species of eucalypts on wood qualities, organic matter, nutrient status, surface water run-off, ground water and water conservation under varying edaphic and climatic conditions and use of fertilizer and pesticides research on these aspects be intensified.

5. With a view to evolve suitable genetic strains of eucalypts to suit various agro-climatic regions, intensive genetic research be undertaken on a priority basis.

6 As eucalypts are being planted as a short-rotation crop to be utilised as small timber, firewood and pulpwood and is being managed under coppice system detailed investigations regarding the extent of its coppicing power and the number of coppice rotations along with the yield should be carried out.

7. As eucalypts are being planted on a large scale by farmers along the field boundaries and sometimes as an inter crop with various agricultural crops like sugarcane, wheat and others, detailed investigations be carried out on the interaction of eucalypts with various agricultural crops.

8. In future before introducing eucalypts in tribal areas, a careful impact study on the welfare of tribal population should be undertaken.

ECONOMICS OF *EUCALYPTUS* PLANTATION—WITH SPECIAL REFERENCE TO UTTAR PRADESH

R.S. MATHUR, S.R. SAGAR AND M.Y. ANSARI

Directorate of Forestry Research,
Forest Research Institute and Colleges, Dehra Dun (India)

Introduction

Among afforested broad leaved species in U P. the *Eucalyptus* occupied 82,132 ha out of total 5,39,1 0 ha plantations raised upto 1978-79. *Eucalyptus* thus constitute about 15% planted area and ranks first among all species planted. The species wise plantation area in U.P. is given below :

Specieswise (broad leaved) Plantation area in U.P (in ha)

Species	Upto 1968-69	During IV Plan 19-9-70 to 1973-74	Total upto 1973-74	During Vth Plan 1974-75 to 1978-79	Grand total upto 1978-79
Eucalyptus	30,761	33,380	64,141	17,991	82,132
Bamboo	27,442	32,723	60,165	20,622	80,787
Teak	14,675	10,593	25,268	14,002	39,2 0
Sissoo	12,548	8,821	21,369	5,213	26,582
Semal Gutel and Ailenthus	6,506	1,657	8,163	1,321	9,464
Khair	3,267	2,965	6,232	3,215	9,447
Sal	4,036	2,179	6,215	883	7,098
Kanjee	576	894	1,470	546	2,016
Mulberry/Paper mulberry	590	1,133	1,723	281	2,004
Misc. and Mixed plantations	1,86,019	42,411	2,28,430	51,950	2,80,380
Total broad leaved species	2,86,420	1,36,756	4,23,176	1,16,004	5,39,180

Source : Forest Statistics, Uttar Pradesh, 1981.

The area considered for this case study relates to Bijnore Plantation Division. This Division is situated at 29°4′ to 29°57′ N latitude and 78°7′ E to 78°41′ E longitudes. The area of the Division is 57,021.7 ha out of which 36,176.3 ha is reserved forests. he terrain is mostly undulating and forms the watershed of rivers Ganga and Ramganga. The soil varies gravely to sandy clay. The mean annual rainfall varies between 865 to 1263 mm with major precipitation during the month of July to August and scanty winter rains during December and January. The temperature of the area varies 45.1°C maximum during June and minimum from 5 to 4°C during December-January The frost occurs during December and January and is harmful for plantations

Eucalyptus hybrid has been planted in this division since 1971 regularly. By 1979, the area under *Eucalyptus* plantation was 14,100 ha. The plantation area are being leased out for agriculture crops for first two years in order to suppress the grasses even though it results in deterioration of environment and soil erosion

The forests of this division meet basic needs of the local people viz. timber for house construction, agricultural implements, firewood, shrubs and bushes for fencing, fodder for domestic animals and many minor forest produce for several needs They supply raw materials to Star Paper Mills, Saharanpur; U.P. Straw and Agro Products Ltd Agawanpur (Moradabad), Agrawal Paper Mills, Muzaffarnagar; Western India Match Factory, Bareilly; Ashok Plywood ,Jawalapur; Himalaya Wood Industries, Haridwar; Chandra Katha Factory, Najibabad, Lakshmi Katha Factory, Najibabad; Bharat Plywood, Najibabad and Amarjoyti Pencil Industry, Kotdwar.

This study relates to the *Eucalyptus hybrid* plantation raised in Mohanwali Block (Compartment No. 2), Jafrabad Block (Compartment No. 4 & 9) and Barahapur Block (Compartment No. 1). The details of the area planted, soil types etc are given in Table 1.

Costs

The plantations were raised with spacing 1.80 metres (6 feet) in lines and ridges about 3.5 metres (about 12 feet) apart. The area was leased out for agricultural crops for first two years. The ridging was done mechanically by Forest Department. The lease holder raised gram, wheat and lahi during Rabi and fodder during Kharif each year. The *Eucalyptus* was planted in the first year by Forest Department on the ridges. It was subsequently maintained for first two years by lease holder and later on by Forest Department. The breakup of the cost per ha is given in Table 2 for all the four plantation sites.

Benefits

The *Eucalyptus* of Mohanwali-2, Barahapur-1 were felled at the age of 8 years, and those of Jafrabad-9, Jafrabad-4 at the age of 9 years and 10 years respectively. The material was sold to U P. Forest Corporation at the rate of royalty Rs. 243/- per m^3. fixed by Government for standing trees The benefits consist of leased amount Rs. 150/-, 100/- per ha for the first two years respectively and the royalty received for the final crop. The diameter class distribution and volume harvested is given in Table 3.

Table 1

Main feature of the Plantation—Bijnore Plantation Division

Soil type, Trees harvested, percentage survival and estimated (QG) harvested volume from 1 hectare plantation area

Range	Block and Compts Nos	Soil Type	Year of planting	Area planted in hectare	Plants planted	Year of felling	Age in years at the time of felling	Trees harvested	Survival (%)	Total estimated outturn m^3 (QG)	Per ha outturn m^3
Kauriya	Mohanwali 2	Yellow, sandy loam and in the marshy area loamy clay	1973	79.47	1,12,524	1981	8	34,563	31	3965.96 (II)	49.90
Kauriya	Jafrabad 9	Sandy plain	19 3	25.00	32,728	1982	9	10,302	32	612.96 (III)	24.52
Bara-hapur	Barahapur 1	Sandy loam plain	1973	8.40	9,625	1981	8	2,886	30	156.12 (IV)	18.58
Kauriya	Jafrabad 4	Sand-mixed	1971	3 00	4,250	1981	10	1,533	36	160.90 (IV)	53 63

Figures within parenthesis indicates quality class.

Table 2

Per hactare cost incurred on different Eucalyptus plantation area of Bijnore Plantation Division (U.P.)

Cost in Rupees per ha

Year	Sl. No.	Head of works and expenditure	Plantation area			
			Mohanwali-2	Jafrabad-9	Barahapur-1	Jafrabad-4
			1416 plants per hectare planted during 1973	1310 plants per hectare planted during 1973	1146 plants per hectare planted during 1973	1416 plants per hectare planted during 1971
(1)	(2)	(3)	(4)	(5)	(6)	(7)
I	1*	Boundary demarcation, site clearance etc.	13	4	6	6
	2*	Fencing-3 strands barbed wire.				
		(a) Cost of felling, debarking and transport of poles, digging of pits, cost of staples, standing of poles and fixing of wire etc.	90	90	90	90
		(b) Barbed wire supplied by Forest Department.	—	—	—	—
	3.	Ridging and lining at 12′ apart done by Govt. tractor only diesel and drivers wages included.	12	12	14	20
	4.	Nursery cost including Pindi making of plants.	410	380	332	402

(Contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	5.	Transport cost of plants to nursery site, loading/unloading Govt. tractor used.	17	13	12	15
	6.	Aldrex/B.H.C. powder.	14	7	8	5
	7.	Planting charges on ridges.	99	44	46	38
	8.	Weeding/hoeing charges.	16	18	18	27
	9*	Huts/stores made by Forest Deptt. for labours.	15	41	10	—
	10*	Roads/Paths/Fireline making.	6	7	7	9
	11.	Forester/Chowkidar/Tools including maintenance of tools.	54	72	63	72
		Total	746	688	606	684
II	1*	Replacement of failure including all cost, viz. maintenance of tools etc.	173	148	143	131
	2.	Fixing of support to the trees.	8	—	—	—
	3.	Chowkidar etc. including umbrella/raincoat.	48	66	57	66
		Total	229	214	200	197
III to felling every year.	1.	Forester/Chowkidar including cost of umbrella, raincoat etc.	48	66	57	66
		Total	48	66	57	66

*Lease holders rendered a help executing these works.

Table

Diameter class distribution, volume harvested

Range	Block and Comp. No.	Area in ha	Quality class	Diameter class distribution					
				0-5	5-10	10-15	15-20	20-25	25-30
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Kauriya	Mohanwali – 2	79.47	II	1867	3114	10520	13428	4998	591
Kauriya	Jafrabad – 9	25.00	III	920	1819	4119	3047	301	30
Barahapur	Barahapur – 1	8.40	IV	182	268	1338	916	172	10
Kauriya	Jafrabad – 4	3.00	IV	56	80	427	539	296	107

3

and Royalty received/ha from the Plantation area

Royalty received Rs. 243 per m^3

in cms				Total No. of trees harvested	Volume estimated in (QG) (m^3)	Per hectare outturn in (m^3)	Per hectare Royalty received from Forest Corporation (Rs.)
30-35	35-40	40-45	45 and above				
(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
45	—	—	—	34.563	3965.96	49 90	12,127
10	22	17	17	10.302	612.96	24.52	5958
—	—	—	—	2886	156.12	18.58	4516
24	4	—	—	1533	160.90	53.63	13,033

Data Analysis

The benefits and costs have been discounted at the interest of rate 12%, 15%, 18% and 20%. The value of N.P.V., B/C ratios and Internal rate of return (IRR) have been calculated for all the four sites seperately. The detailed analysis is presented in Table 4, 5, 6 and 7 for Mohanwali-2, Jafrabad-9, Barahapur-1 and Jafrabad-4 respectively.

Table 4

Cost Benefit Analysis of one ha of Eucalyptus Plantation at Mohanwali - 2 Planted during 1973 and Exploited at 8 years of age during 1981-82

Years	Average total cost incurred (Rs.)	Benefit received (Rs.)	Net Benefit (Rs.)	Discounted at interest rate			
				12%	15%	18%	20%
1	746	150*	—596	– 596	—596	—596	—596
2	229	100*	—129	—115	—112	—109	—107
3	48	—	— 48	— 38	— 36	— 34	— 33
4	48	—	— 48	— 34	— 32	— 29	— 28
5	48	—	— 48	— 31	— 27	— 25	— 23
6	48	—	— 48	— 27	— 24	— 21	— 19
7	48	—	— 48	— 24	— 21	— 18	— 16
8	48	12,127	+12079	+5463	+4540	+3792	+3370
Net present value in Rs.				4598	3692	2960	2548
Benefit/Cost Ratio				1 : 5.08	1 : 4.35	1 : 3.73	1 : 3.38
Internal rate of return				49.12%			

* This amount received from lease holder.

Table 5

Cost-Benefit Analysis of one ha of Eucalyptus Plantation at Jafrabad - 9 Division - U.P Planted during 1973 and Exploited at 9 years of age during 1982-83

Years	Average total cost incurred (Rs.)	Benefit received (Rs.)	Net Benefit (Rs.)	Discounted at interest rate			
				12%	15%	18%	20%
1	688	150*	—538	—538	—538	— 538	—538
2	214	100*	—114	—102	— 99	— 96	— 95
3	66	—	— 66	— 53	— 50	— 47	— 46
4	66	—	— 66	— 47	— 44	— 40	— 38
5	66	—	— 66	— 42	— 38	— 34	— 32
6	66	—	— 66	— 37	— 33	— 29	— 26
7	66	—	— 66	— 33	— 28	— 24	— 22
8	66	—	— 66	— 30	— 25	— 21	— 18
9	66	5958	+5892	+2379	+1926	+1567	+1370
Net present value in Rupees				1497	1071	738	555
Benefit/Cost Ratio				1 : 2 30	1 : 1 96	1 : 68	1 : 1.52
Internal rate of return				29.2%			

* This amount received from lease holder.

Table 6

Cost Benefit Analysis of one hectare of Eucalyptus Plantation at Barahapur-1 U.P. Planted during 1973 and exploited at 8 years of age during 1981-82

Years	Average total cost incurred (Rs.)	Benefit received (Rs.)	Net Benefit (Rs.)	Discounted at interest rate			
				12%	15%	18%	20%
1	606	150*	—456	—456	—456	—456	—456
2	200	100*	—100	— 89	— 87	— 85	— 83
3	57	—	— 57	— 45	— 43	— 41	— 39
4	57	—	— 57	— 40	— 37	— 35	— 33
5	57	—	— 57	— 36	— 32	— 29	— 27
6	57	—	— 57	— 32	— 28	— 25	— 23
7	57	—	— 57	— 29	— 24	— 21	— 19
8	57	4516	+4459	+2017	+1676	+1400	+1244
Net present value in Rs.				1290	969	708	564
Benfit/Cost Ratio				1 : 2 30	1 : 2.00	1 : 1.75	1 : 1.61
Internal Rate of Return				32.36%			

* This amount received from lease holder.

Table 7

Cost Benefit Analysis of one hectare of Eucalyptus plantation at Jafrabad-4 Planted during 1971 and exploited at 10 years of age during 1981-82

Years	Average total cost incurred (Rs.)	Benefit received (Rs.)	Net Benefit (Rs.)	Discounted at interest rate			
				12%	15%	18%	20%
1	684	150*	—534	—534	—534	—53.	—534
2	197	100*	— 97	— 87	— 84	— 82	— 81
3	66	—	— 66	— 53	— 50	— 47	— 46
4	66	—	— 66	— 47	— 44	— 40	— 38
5	66	—	— 66	— 42	— 38	— 34	— 32
6	66	—	— 66	— 37	— 33	— 29	— 26
7	66	—	— 66	— 33	— 28	— 24	— 22
8	66	—	— 66	— 30	— 25	— 21	— 18
9	66	—	— 66	— 27	— 22	— 18	— 15
10	66	13,033	+12967	+4676	+3685	+2923	+2513
N*t present value in Rs.				3786	2827	2094	1701
Benefit/Cost Ratio				1 : 4.28	1 : 3.53	1 : 2.94	1 : 2.61
Internal Rate of Return					38.50%		

* This amount received from lease holder.

The summary results of cost-benefit analysis is given in Table No. 8.

Discussion of the results

The three parameters i.e. the Net Present Value (NPV), the Benefit-Cost Ratio (B/C ratio) and the Internal Rate of Return (IRR), have given encouraging results.

The survival percent ranges nearly 30-36 and such poor survival was attributed to lessee farmers. Although the cost of plantation and maintenance for initial two or three years was reduced but the extent of damage has been found greater in final yield. As such this practice of raising *Eucalyptus* needs modification.

The correlation between quality class, age of felling and parameters of cost-benefit analysis remains inconclusive due to lack of sufficient data on each quality class and age of felling. There is need of further studies for coming to any definate conclusion in establishing a correlation between these parameters.

Table 8

Summary results of Cost-Benefit Analysis for different plantation sites of Bijnore Plantation Division, U P.

Range	Block and Compt.	Quality class	Age at the time of felling (years)	Nature of analysis	Rate of interest (%)				Internal rate of return in (%)
					12%	15%	18%	20%	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Kauriya	Mohanwali-2	II	8	NPV in Rs.	4598	3692	2960	2458	
				B/C Ratio	1 : 5.08	1 : 4.35	1 : 3.73	1 : 3.38	49.12
Kauriya	Jafrabad-9	III	9	NPV in Rs.	1497	1071	738	555	
				B/C ratio	1 : 2.30	1 : 1.96	1 : 1.68	1 : 1.52	29.2
Barahapur	Barahapur-1	IV	8	NPV in Rs	1290	969	708	564	
				B/C ratio	1 : 2.30	1 : 2.00	1 : 1.75	1 : 1.61	32.36
Kauriya	Jafrabad-4	IV	10	NPV in Rs.	3786	2827	2094	1701	
				B/C Ratio	1 : 4.28	1 : 3.53	1 : 1.94	1 : 2.61	38.50

NPV–Net Present value
B/C –Benefit Cost

Acknowledgement

Authors gratefully acknowledge the help rendered by Shri C.P. Naithani, IFS and Shri Bishmbher Singh, ACF in collection of data. Thanks are also due to Shri L.S. Rana for his valuable help and to Shri S K. Mehta for data collection.

SUMMARY

Large scale plantations of *Eucalyptus* were started in 1962 in the tarai region of U.P. in mixed poor stocked forests or grassy blanks within or closer to the forests. The total area upto 1978-79 under *Eucalyptus* plantations in different forest circle of U.P. was 82,132 hectare while the total area under all other broad leaved species was 5,39,180 ha. At present *Eucalyptus* is raised in large scale plantation programme by the Forest Department as well as by the individuals all over the country.

The present study is concerned with 116 hectare *Eucalyptus* plantations which were established in 13 different plots during 1971 and 1973, in the Bijnore Plantation Division. Main crop of these plantation was exloited during 1981-82, and produced 4895 & 9518 m³ (Q.G) logs and firewood for which royalty received This study reveals that *Eucalyptus* plantations are economically feasible

उत्तर प्रदेश के विशेष सन्दर्भ में—युकेलिप्टस रोपवनों का अर्थशास्त्र

लेखक आर०एस० माथुर, एस०आर० सागर व एम०वाई० अंसारी

सारांश

उत्तर प्रदेश के तराई क्षेत्र में अघन लगे हुये मिश्र वनों अथवा वनों में या उनके निकट छुटे हुए रिक्त घास क्षेत्रों में बड़े परिमाण पर युकेलिप्टस रोपवन लगाना 1962 से शुरू कराया गया। 1978-79 तक इस प्रकार लगाया गया युकेलिप्टस रोपवन क्षेत्र उत्तर प्रदेश के विभिन्न वृत्तों में 82,132 हेक्टेयर रहा जबकि अन्य सभी पृथुपर्ण वृक्ष जातियों का कुल क्षेत्र 5,39,180 हेक्टेयर है। इस समय युकेलिप्टस बड़े परिमाण पर वन विभाग के रोपण कार्यक्रमों के अन्तर्गत तथा अन्य व्यक्तियों द्वारा भी देश में सर्वत्र लगाया जा रहा है।

प्रस्तुत अध्ययन का सम्बन्ध युकेलिप्टस के 116 हेक्टेयर के उन रोपवनों से है जिन्हें 1971 और 1973 में विभिन्न भूखण्डों में, बिजनौर रोपवन मण्डल में लगाया गया है। इन रोपवनों की मुख्य फसल की कटाई 1981-82 में कराई गई जिससे 4895 व 9518 घनमीटर (चतुर्थांश चिरे) लट्ठे और ईंधनकाष्ठ प्राप्त हुये जिनसे स्वत्वशुल्क मिला। इस अध्ययन से पता चलता है कि युकेलिप्टस रोपवन आर्थिक दृष्टि से भी लाभप्रद रहते हैं।

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GROUND WATER QUALITY (pH) UNDER DIFFERENT VEGETATIVE COVERS AT OSAMUND (NILGIRI HILLS)

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Introduction

Groundwater is an important source of water supply throughout the world. Its use in irrigation, industries, municipalities and rural as well as urban areas continues to increase. The total groundwater present in the biosphere is 2,000,000 cubic miles out of the total water content of 326,000,000 cubic miles (Periera *et al.*, 1970) which comprises of about 0.6 per cent of the total. In India, the utilisation of groundwater is estimated to be 103 billion m^3 out of total groundwater potential of 281 billion m^3 which works out roughly to 40 per cent (Anon. 19 0). Forests play a key role in the development of groundwater resources. The aquifers under forest can be managed to serve as underground reservoirs to store monsoon rains for use during dry periods. Artificial recharge of forest lands may be planned to store maximum volume of water underground when it is available at the surface. Underground reservoirs require no gigantic structures, occupy no additional land area, no distress of eviction and do not cause much evaporation loss (Banerji & Lal, 1971.) Before taking up a ground-water Development Project, it is necessary to study the groundwater quality particularly when there is a possibility of it's being modified by the plantation of exotic trees like *Eucalyptus*. One very important determinable groundwater parameter is its pH.

When it rains, a part of rain water infiltrates into the soil and moves both laterally and vertically till it reaches a saturated zone. It is this part of rain water which forms the ultimate source of groundwater supplies Ordinarily, higher proportion of dissolved salts are found in groundwater than surface water as salts are added due to longer exposure to the soluble materials in geologic strata (Mathur, 1980). pH of groundwater indicates presence of salts under particular land use geological formation and thus determines its utility for irrigation and drinking purposes. The availability of soil nutrients to plants is also dependent upon the pH of groundwater. If water is acidic, it may result in higher solubility of nutrients, which may ultimately result in toxicity to the plants. The suitability of groundwater for irrigation is contingent upon the effects of mineral constituents of water on both plant and soil Thus pH of groundwater is an important factor in maintaining quality of water. In India not much data is available on pH of ground. water under forests. Taking into consideration of these facts, a study was initiated to find out the effect of afforestation with *Eucalyptus globulus* on pH of groundwater.

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Description of the Experimental Area

A small area under *Eucalyptus globulus*, natural Shola forest and grassland forming a separate watershed was taken for monitoring pH of groundwater. This area is representative of high hill of Nilgiri District (Tamil Nandu) with gently rolling downs and it lies in Wenlock Down Reserved Forest of Parsons Valley Range about 18 km on Ooty, Mysore Highway The place receives normal yearly rainfall 2040.6 mm out of which 1609 mm (80%) are received between June to December. Both the South-West and North-East monsoons are active in this part of the country. The Summer is characterised by (warm) temperatures upto 28°C during which pleasant climate prevails. Winter months are severely cold with temperatures as low as -2°C The average elevation is 2200 m with a gross relief of 96 m. The gross slope of the main channel is 10 per cent. The catchment area is 6.56 ha. The soils in the area are clayey in texture, acidic in reaction and high in organic content. Before plantations were taken up the area was covered with a thick mat of natural grass typical of the Wenlock Downs and consisted of *Chrysopogon zeylenicus, Andropogon polyptychus*, *Themeda triandra* etc.

In low-lying pockets some Shola forests existed. The area was originally planted 1958 with *Eucalyptus globulus* and was first coppiced in 1968 after which coppice shot up again. Now (1982) the coppice crop is 14 years old. There are 4097 trees in the Catchment (Fig 1). They were planted with average spacing of 2 m × 2 m. The average height of trees is 22 m and average diameter at breast height is 16 cm for main coppice shoots. The rainfall data for the period of study is shown in Table 1.

Table 1

Rainfall (mm) data for Osamund Experimental Watersheds, Nilgiris

Year	Months												Total
	J	F	M	A	M	J	J	A	S	O	N	D	
1980	0.0	0.0	31.6	86.9	107.4	331.6	317.2	76.0	107.0	146.3	141.9	1.6	1347.5
1981	0.0	0.0	43.0	17.5	89.2	215.2	160.5	237.2	258.5	173.7	33.5	13.2	1241.5
1982	0.0	0.0	8.4	43.6	162.8	236.5	179.5	313.4	81.3	167.0	127.2	11.1	1330.8
1983	0.0	0.0	—	—	—	—	—	—	—	—	—	—	-

Methodology

Groundwater samples were collected from piezometric holes drilled in grassland, natural Shola forest and *Eucalyptus globulus* plantation. These holes are drilled with the help of posthole soil augers and protected by a masonry parapet around. The depths of piezometric holes in grassland, blue-gum and Shola are 5,11,8 m respectively Groundwater samples are collected once in a fortnight, transported to the laboratory and the pH of the samples are determined using a transistorised pH meter The data on pH of groundwater is available from July, 1980 onwards. Tables 2 and 3 show abstract of data collected.

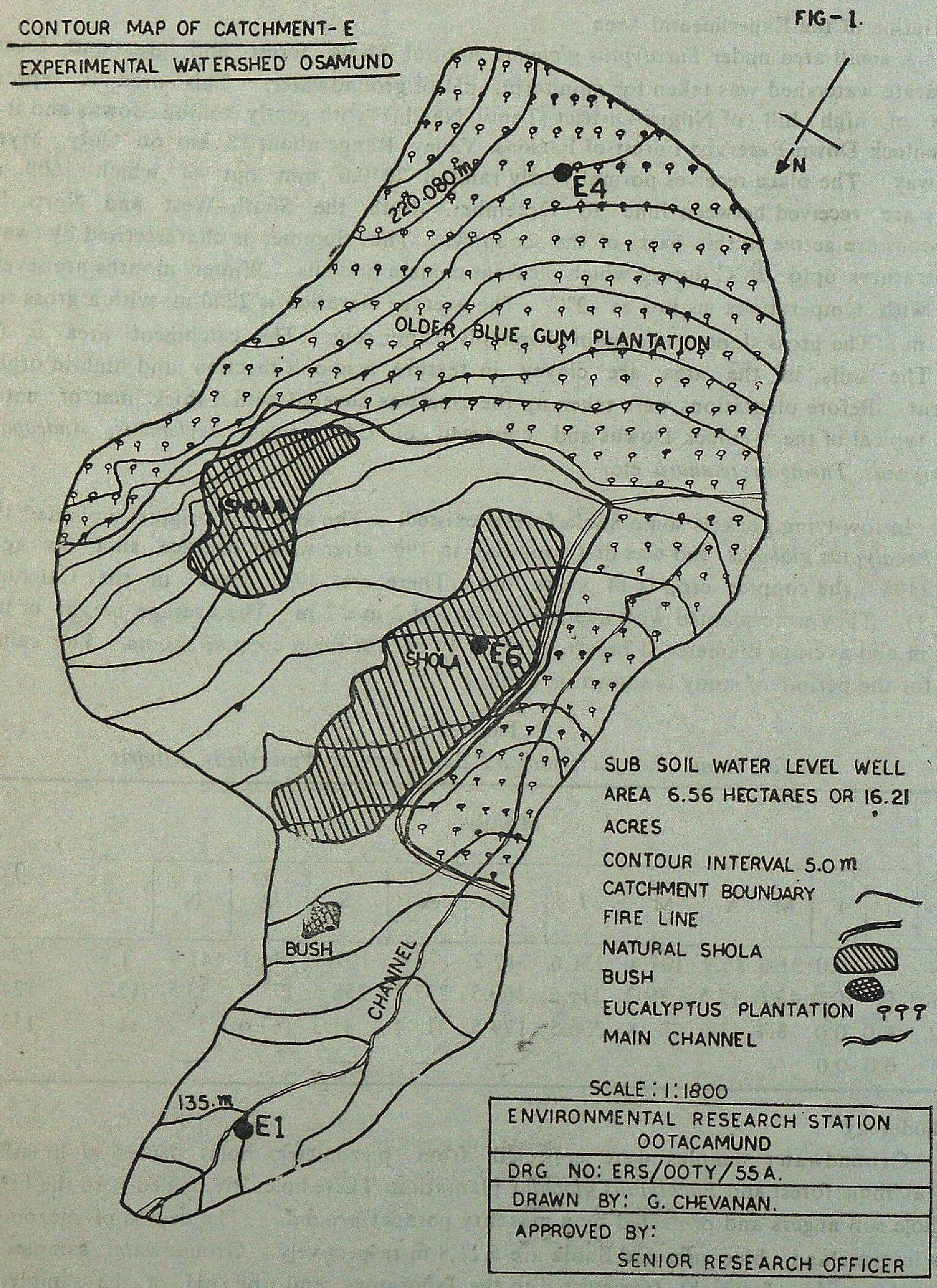
CONTOUR MAP OF CATCHMENT- E
EXPERIMENTAL WATERSHED OSAMUND
FIG-1.
N
220.080 m
E4
OLDER BLUE GUM PLANTATION
SHOLA
SHOLA
E6
BUSH
CHANNEL
135. m
E1
SUB SOIL WATER LEVEL WELL
AREA 6.56 HECTARES OR 16.21 ACRES
CONTOUR INTERVAL 5.0 m
CATCHMENT BOUNDARY
FIRE LINE
NATURAL SHOLA
BUSH
EUCALYPTUS PLANTATION
MAIN CHANNEL
SCALE : 1:1800
ENVIRONMENTAL RESEARCH STATION OOTACAMUND
DRG NO: ERS/OOTY/55 A.
DRAWN BY: G. CHEVANAN.
APPROVED BY:
SENIOR RESEARCH OFFICER

Table 2

Abstract of data on pH of groundwater

	Grass (E1)	Shola (E6)	*Eucalyptus globulus* (E4)	Remarks
Number of sample (N)	62	61	54	Data from July 80 to March 83
Average pH (X)	6.04	5.91	6.07	
Standard Deviation (O)	0.84	0 73	0.60	

Table 3

Average pH of Groundwater during Monsoon and Non-Monsoon

	Grass				Shola				*Eucalyptus globulus*			
	1980	1981	1982	1983	1980	1981	1982	1983	1980	1981	1982	1983
Monsoon	5.9	5.9	5.4	—	6.2	5.9	5.6	—	5.9	5.6	5.9	—
Non-Monsoon	—	6.0	6.9	6.7	—	6 3	6.3	6.7	—	6.2	6.3	6.7

Analysis of Data

(a) *To evaluate the effect of vegetation on pH of groundwater.* Three types of vegetation viz. grassland, Blue-gum plantation and Shola forests were taken up and groundwater samples were collected at fortnightly interval from wells existing in the three types of vegetation. The studies were conducted from July, 1980 to Feb., 1983 and 62, 54, 61 samples were collected from grassland, blue-gum and Shola respectively.

Table 4

Average pH values under different plant covers

	Grassland	Blue-gum Plantations	Shola forest
Average pH	6.04	6.07	5.91
Standard Deviation	0.84	0.60	0.73
Number of samples	62	54	61

CD ± 1.96 Not significant at 5% level.

(b) *Effect of Rainfall on pH of groundwater*. Under each vegetation, groundwater samples were collected during monsoon and non-monsoon period. Monsoon rains occur from June to December and period from January to May are taken as non-monsoon months. 25, 20 and 25 samples were collected in non-monsoon period and 37, 34 and 36 samples were collected in monsoon respectively from grassland, Blue-gum plantations and Shola forests. The statistical particulars are given as under .

Table 5

Variation in pH under different plant covers during monsoon (June-Dec) and non-monsoon (Jan-May) at Osamund Nilgiri.

	Grassland		Blue-gum		Shola	
	Monsoon	Non-Monsoon	Monsoon	Non-Monsoon	Mousoon	Non-Monsoon
Average pH	5 71	6.52	5 89	6.37	5.60	6.35
Standard deviation	0.67	0.84	0 53	0.61	0 64	0.63
Number of samples	37	25	34	20	36	25

C.D. ± 1.6 Significant at 5% level in all the three.

At a significance level of 0.05, the table value of t for degrees of freedom greater than 30 is ± 1.96 as t distribution approaches normal distribution for d.f. greater than 30.

In all the three cases, the calculated value of CD is greater than the critical value of ± (1.96) and we may conclude that there is significant difference in the average values of pH between monsoon and non-monsoon. Therefore, the effect of rainfall is to reduce the pH value of groundwater during the monsoon.

Results and Discussions

The results indicate that there is no significant effect leave alone an adverse effect, on groundwater pH due to vegetal covers. Views expressed by some people and environmentalists that large scale plantation of *Eucalyptus globulus* in Nilgiris causes adverse effect to the groundwater quality is not substantiated by this study and on the contrary proves that there is no adverse effect on groundwater pH due to Blue-gum plantations or natural Shola forests even though both the area contain heavy leaf-litter accumulation in partially or highly decomposed state. However, seasonal variation in groundwater pH is noticeable in rainy and dry seasons in the three types of vegetation. The groundwater becomes more acidic in rainy season than it is in the winter season. This information is to be taken into consideration for (basin-wide) development of groundwater and such studies are to be carried on all aspects of groundwater quality.

Acknowledgements

The authers are grateful to Shri K.M. Tiwari, President, F.R.I. & Colleges, Dehra Dun for affording necessary facilities to carry out these studies and for his guidance, suggestions, continued interest and encouragement in the activities of the Research Centre. The authors are thankful to Shri K. Rajgopal, T.A. I who collected the samples and to Shri G S. Maurya, RA. I who did laboratory analysis. The authors are thankful to Mrs. N. Indira, L.D.C. for typing the manuscript and to other staff of the Centre who assisted in the study.

SUMMARY

Groundwater is one of the important sources of water supply and vegetation plays its role in maintaining the quality and quantity of groundwater. However, little data is available in our country on the quality and quantity of groundwater resources as affected by vegetation. Of the many qualities of groundwater, pH measurements under different vegetative covers was taken for studies. Groundwater samples were collected at fortnightly intervals for two years from piezcmetic wells existing in three vegetative covers viz. *Eucalyptus* plantation, Shola forest and grassland, the samples were analysed for pH. The study indicated no adverse effect on pH of groundwa'er due to different vegetal covers. However, there is noticeable seasonal variation in pH values of groundwater. in the rainy season (pH 5.60) the groundwater becomes more acidic than it is in the dry season (pH 6 52).

ओसमुण्ड (नीलगिरी) में विभिन्न वनस्पति आवरणों में भूमि जल के गुण (पी एच)

लेखक एच०एन० माथुर, एस० फ्रांसिस हिलेरी राज व संजय नैथाणी

सारांश

भूमि का जल हमारे जल प्रदाय के महत्वपूर्ण स्रोतों में से है तथा भूमि जल के गुण और परिमाण ठीक-ठीक बनाये रखने में वनस्पतियों की महत्वपूर्ण भूमिका रहती है। इतना होने पर भी देश में, विभिन्न वनस्पति आवरणों से प्रभावित हुए भूमि जल के गुणों और परिमाण के सम्बन्ध में बहुत कम जानकारी मिलती है। भूमि जल के अनेक गुणों में से पी एच को विभिन्न वनस्पति आवरणों के अधीन माप कर इस अध्ययन में लिया गया है। एक-एक पखवाड़े का अन्तराल देकर दो वर्ष तक भूमि जल के नमूने तीन वनस्पति आवरणों अर्थात् युकेलिप्टस ग्लोबुलुस रोपवन, शोला वन और घास क्षेत्र में बने हुए पीडमान कुंओं से इकट्ठे किये जाते रहे और उन नमूनों का पीएच विश्लेषित किया गया। इस अध्ययन से पता चला है कि विभिन्न वनस्पति आवरणों से भूमि जल के पीएच पर कोई कुप्रभाव नहीं पड़ता है। किन्तु, भूमि जल के पीएच मान में दृश्यमान मौसमी अन्तर होता पाया गया और शुष्क मौसम (पीएच 6.52) की तुलना में वर्षा ऋतु में पीएच अधिक अम्लीय (पीएच 5.60) हो जाता हैं।

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A NEW APPROACH TO SEASONING OF *EUCALYPTUS HYBRID* (*EUCALYPTUS TERETICORNIS*)

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Introduction

For meeting the ever increasing demand for fuel and pulp wood, large scale plantations of *Eucalyptus hybrid* have been raised in almost all states of India during the last twenty years. Although the first attempt at raising large scale plantations of *Eucalyptus* for fuel wood was made with *E. globulus* in the middle of last century in Nilgiri and Palni Hills in Tamil Nadu but at present *E. tereticornis* is the commonest of all the *Eucalyptus* species used for raising such plantation. It was earlier considered to be a hybrid, and was popularly known as Mysore hybrid. Pryor, however has shown that it is in fact *E. tereticornis* and has suggested that the trees raised from the seeds of Nandi Hill provenance should be called Mysore Gum. It was first raised on plantation scale in Karnataka State in 1952 and subsequently introduced on experimental basis in other states, from the seeds obtained from Nandi Hills. In Punjab and Haryana, where the area under forest is negligible, *E. tereticornis* has been planted in strips along the important highways, canals and railways. It is estimated that upto 1977, this species had been planted over an area of about 4,28,000 ha in different parts of the country (Ghosh *et al.*, 1977).

Initially most of the plantations of *Eucalyptus* were raised for fuel and pulp wood, but due to continuous increasing pressure on some of the primary species, it has focused our attention on the utilization of *Eucalyptus* as timber As a result considerable work has been done on the suitability of this timber for different end uses Sekhar and others have evaluated physical and mechanical properties of *Eucalyptus hybrid* of 8 years age from Mahakanam Division, Tamil Nadu classifiying the timber as heavy, moderately strong. moderately tough and hard timber (Sekhar *et al*, 1968). Based on the tests carried on timber of 3 age classes from three different localities of Karnataka, Jain is of the view that with the increase in the age of the tree, strength values for practically all the properties increase except in case of impact bending where the value decreases. He is of the view that the wood acquires at steady state of strength at the age of 13 to 14 years and does not make any significant additions in it with subsequent growth (Jain, 1969).

Inspite of all these works the use of *Eucalyptus* as sawn timber by and large has been a failure because of its poor seasoning behavior (Purkayastha, 1982). *Eucalyptus* being a highly refractory timber develops severe collapse, surface cracks, warping and twisting during the process of air or kiln seasoning. Work carried out by the previous workers have shown that

pretreatment with urea eliminated surface and end cracking but not the collapse and warping which are the major defects noticed in the tangentially sawn planks (Purkayastha, 1982). Attempts have therefore been made to eliminate the various types of seasoning defects by adopting the quarter sawing (radial sawing) process of conversion of log and developing a new seasoning schedules for drying of the sawn timber. A detail account of this is described in this paper.

The effect of conversion of log on the seasoning behaviour

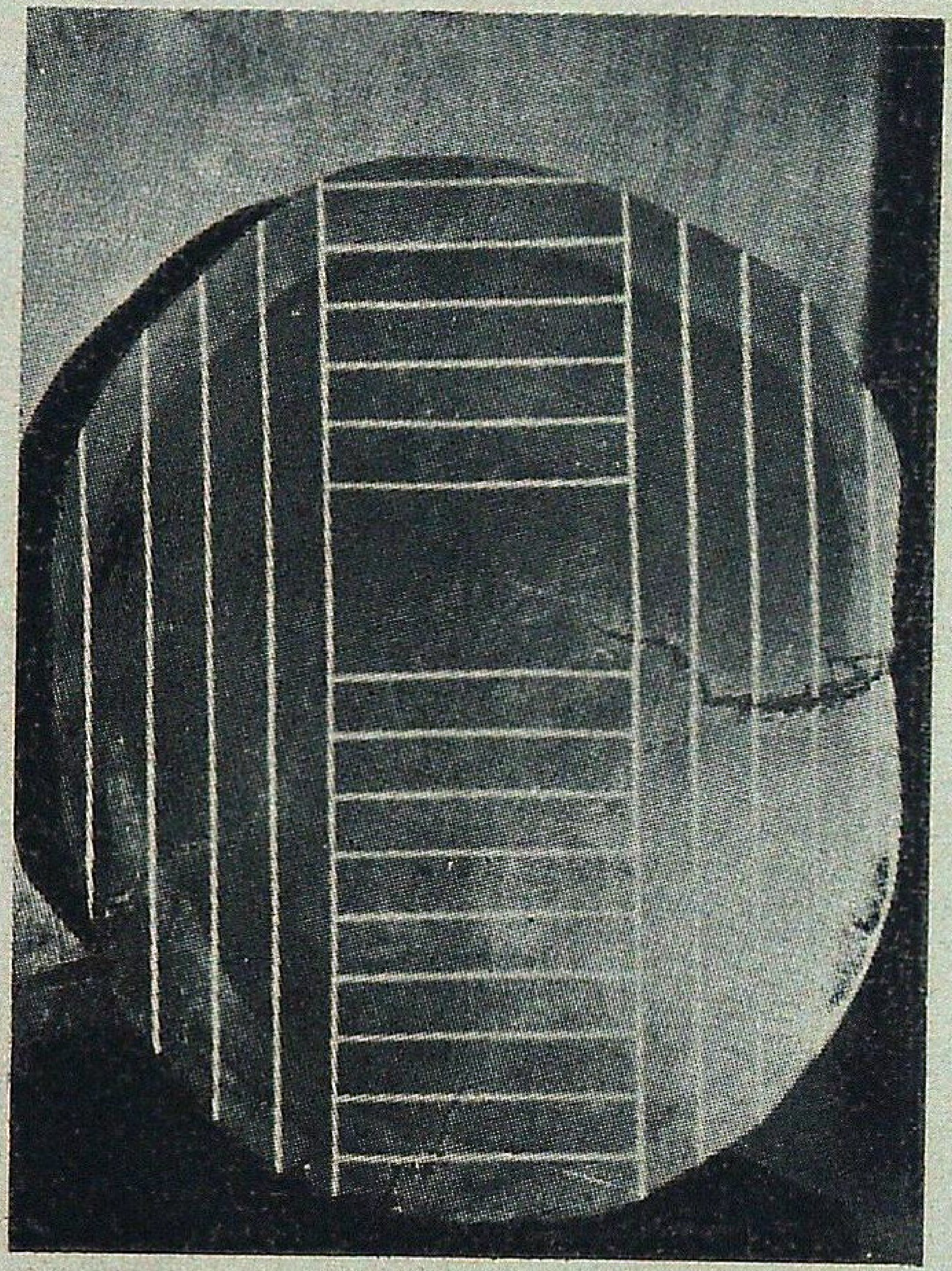
In a standing tree the outer trunk of the green *Eucalyptus* is in a state of tension along its longitudinal axis and the inner wood in a corresponding state of compression. The forces involved are considerable. The average stress in the outer most layer is approximately 84 kg/cm^2 while the compressive stresses are often greater than 140 kg/cm^2. The outer tension stress is resisted by the inner layers of the stem resulting in a longitudinal strain gradient across any diameter (Chaturvedi, 1983). The inner layers become compressed and the outer most layers are crushed beyond the elastic ability of wood to resist longitudinal compression. Under these severe forces the cell of the inner wood fails in course of time. Under such condition if a *Eucalyptus* log is cut lengthwise tangentially (see Plate 1) which is the common practice used for the conversion of other species of timber, the release of inner compression makes the inside edge of the resulting plank longer (when cut) than it was in tree and the outer wood contracts, becoming shorter out of tree (when cut) than in tree. A longitudinal piece of wood that was straight in tree becomes a curve out of tree with its convex edge facing the pith. The conversion of *Eucalyptus* log to tangential planks therefore creates problems during the process of subsequent drying and develops various types of seasoning defects viz. collapse, warping, surface cracking, twisting etc. (see Plate 2)

However, these problems can be avoided by cutting the log lengthwise radially (i.e. sawn with the wide face along the original radius of the log), see Plate 3 and Plate 4.

Material and Method

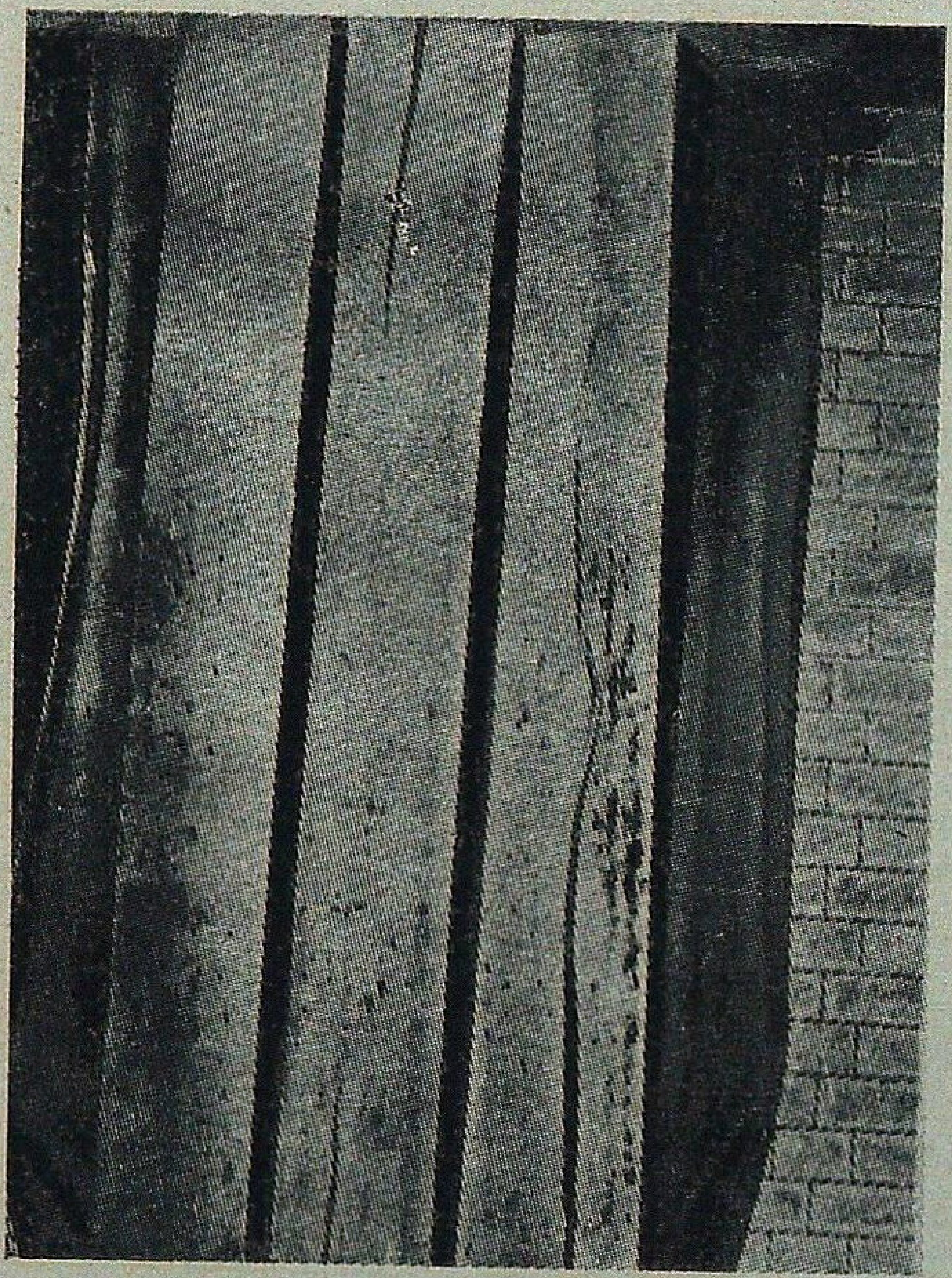
25 logs of length 2 metres and girths of approximately .80 to 1.2 metres from the freshly felled trees of *Eucalyptus tereticornis* were procured from the Haryana Forest Department. Immediately after felling and cross cutting into logs the freshly cut ends were coated with bituminous paints in order to avoid end splitting and cracking during the process of their storage. However, some splitting and cracking at the ends were noticed, despite the use of end coating, perhaps due to the unbalancing of previously balanced internal stresses in standing tree. From each log, half the portion were converted tangentially and remaining into radial planks of 25 mm thickness. The mixed stock of these radial and tangential sawn planks, were stacked in a steam heated kiln and seasoned using the following kiln schedule.

Plate 1



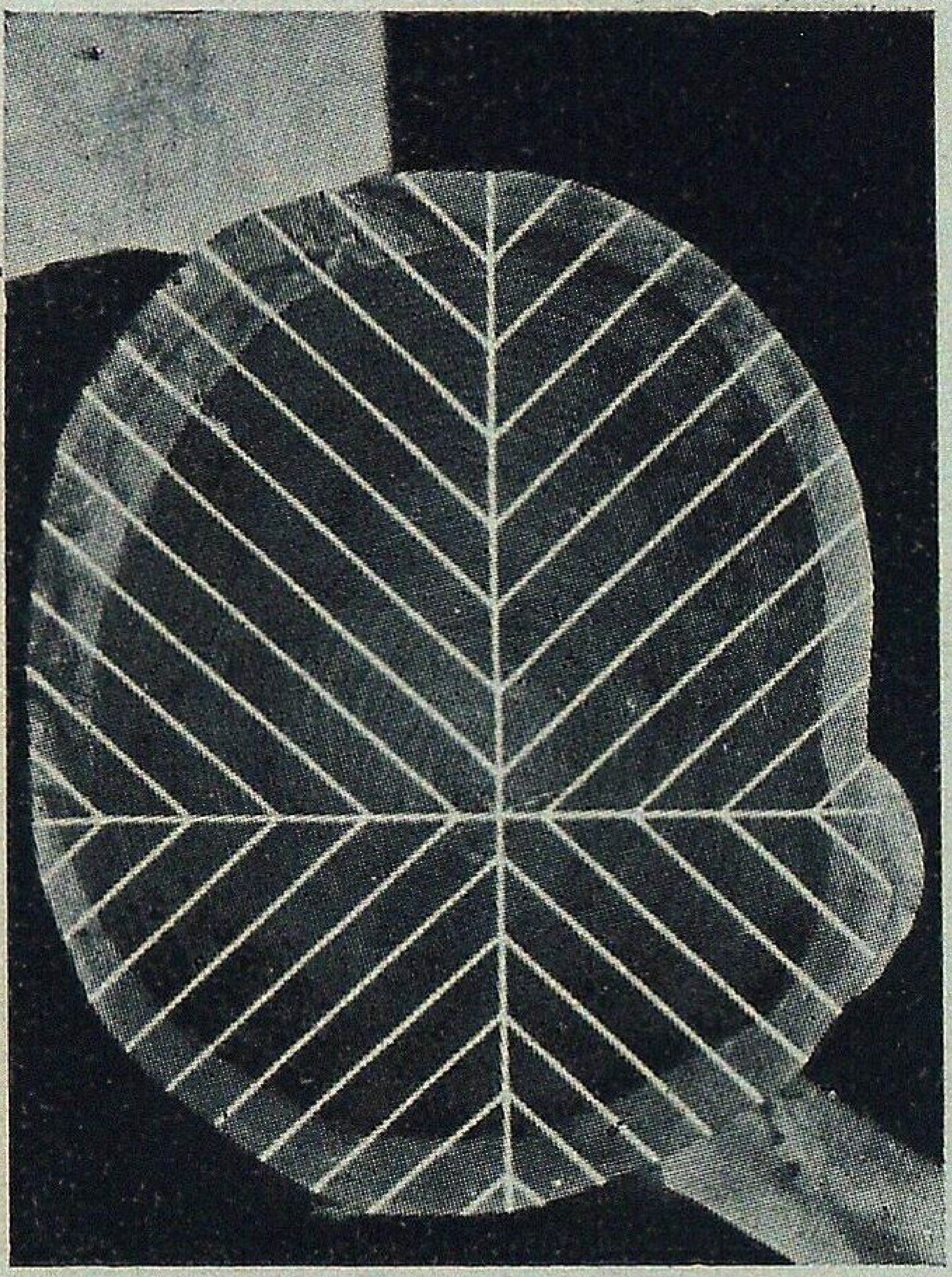
Tangential sawing method of *Eucalyptus* log

Plate 2



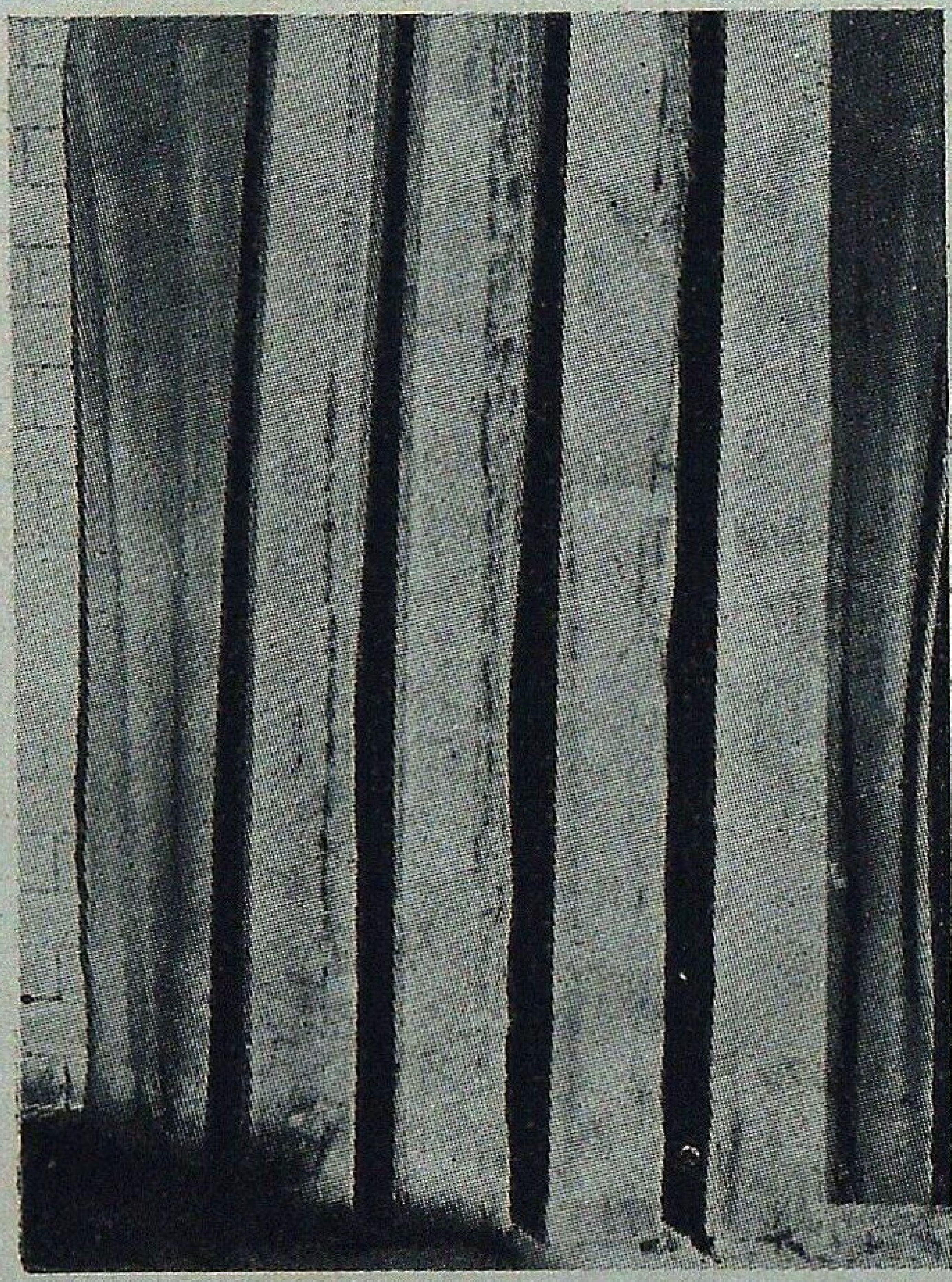
Planks develop splitting, surface cracking, warping etc. during kiln seasoning

Plate 3



Radial sawing method of *Eucalyptus* log

Plate 4



Defect free planks after kiln seasoning

M.C. Charge point %	Dry bulb temp.°C	Wet bulb temp.°C	Relative humidity
Green	43	40	82
50	44	40	77
35	49	43	69
25	55	45	55
20 to final	60	45	42

Note : In addition to initial and final steaming for 3 hours an intermediate steaming for nearly 4 hours at 55°C was given during the process of seasoning in a steam heated klin.

Result and Discussion

The seasoning results indicated that approximately 10 to 12 days (24 hrs per day) are required to kiln dry 25 mm radial sawn *Eucalyptus tereticornis* planks from the green condition to 12% moisture content. It was observed that tangential planks are extremely difficult to season free from collapse, end and surface cracking and face checking, where as the radial sawn planks did not show any such defects. In addition to these seasoning defects in the tangential plank it was also observed that if a green log is converted tangentially nearly 15–20% of the planks developed immediate splitting and cracking due to presence of severe strain gradient across the diameter of the logs which was not observed in the case of radially sawn planks. Based on the above observations, the best result during the process of seasoning of *E. tereticornis* can be obtained by adopting the under mentioned practices.

(1) Immediately after felling and cross cutting into logs the freshly cut ends should be coated with a good protective moisture seal viz bituminous paints and should be debarked and stacked properly under shed.

(2) The logs should not be stored for a long period as they tend to split at ends and crack along the length and the wood becomes hard to saw.

(3) The logs should be converted into radial planks only, as far as practicable.

(4) Due allowance should be made for shrinkage while converting the material into final sizes for example, timber to finish 25 mm thick when dry should be sawn 28 mm thick in green and timber to finish 50 mm thick when dry should be sawn 56 mm thick when green.

(5) The above mentioned seasoning schedule should be followed for the drying of 25 mm thick green radial planks.

(6) The seasoning of thicker timber may be carried out cheaply, and with less degrade by combining a preliminary period of 60 to 90 days air seasoning (to a moisture content of about 25–30%) with final kiln drying. For timber that has been

partly air dried to a moisture content of about 30 per cent, about 6 to 7 days are required for final kiln drying to a moisture content of 12 per cent.

Further work on the seasoning of *Eucalyptus* of bigger cross section is under study for their utilization as doors and window frames etc.

Limitations

The radial sawing can easily be employed in case of logs of bigger girth (approx. 1 m) but is not possible in case of smaller girth logs because of economic reasons. However, logs of small girth may be used as such for fence post, overhead power and telecommunication lines etc , after chemical treatment.

Acknowledgements

The authors are thankful to the Chief Conservator of Forests, Haryana for supplying the *Eucalyptus* logs, free of cost for this experiment. Thanks are also due to the Officer-in-Charge, Service Branch, for arranging the conversion of logs to planks.

SUMMARY

Eucalypts being a highly refractory timber develop severe collapse, surface cracks, warping and twisting during the process of air or kiln seasoning in tangentially sawn planks, which is a conventional and most commonly used process. The adoption of radial sawing of eucalypt logs have shown that defect free planks can be obtained and can be subsequently seasoned also without cracking, collapse or warping defects. New seasoning schedules for seasoning of *Eucalyptus* planks of 25 mm thick have also been evaluated.

संकर युकेलिप्टस (युकेलिप्टस टेरेटिकार्निस) का संशोषण करने की एक नई युक्ति

लेखक सी०एन० पाण्डे, बी०के० गौड़, एच०सी० कन्नौजी ब आकाश चन्द्र

सारांश

अत्याधिक अप्रतिचारी प्रकाष्ठ होने से युकेलिप्टस के स्पर्शरेखीय चीरे हुये तख्तों का वायु या आपाक संशोषण कराते समय जो कि इसका उपयोग करने की सबसे अधिक व्यवहृत पारम्परिक रीति है, इसमें भारी भंग, स्तरीय तिड़कन, मरोड या ऐंठनें पड़ जाती हैं।

युकेलिप्टस के तख्तों का अरीय चिरान करने की रीति अपनाने पर यह पता चला है कि उससे दोष रहित तख्ते तैयार किये जा सकते हैं जिनका बाद में बिना तिड़कन, भंग या मरोड़ दोष आए संशोषण भी किया जा सकता है। 25 मि मी० मोटे युकेलिप्टस के तख्तों का संशोषण करने की नई संशोषण तालिकाएं भी तैयार की गई हैं।

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DISTRIBUTION OF ORGANIC MATTER AND NUTRIENT CONTENT IN A *EUCALYPTUS* HYBRID PLANTATION ON LATERITIC SOIL IN WEST BENGAL

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Introduction

The forests of Southern West Bengal comprise of Sal forests of coppice origin which are in various stages of degradation due to maltreatment in the past while under private management. There had remained practically no tree growth over a large area, such area having turned into mere scrub jungle and/or blanks at various stages of erosion. The remaining area is covered with sal coppice forest of variable density grown out of stumps of unknown age of probably 100 years or more. Present outturn from a coppice coupe is about 38 m³ per ha mostly in the form of sal firewood and some poles.

About 1200 km² of the forests of this zone has been earmarked for production of industrial wood by raising plantations of quick growing species. With this objective in view, raising of *Eucalyptus* hybrid (Mysore gum) was started in this tract in the year 1961. *E.* hybrid has been found to grow satisfactorily in this zone with adequate manuring as the soil is much deficient in soil nutrients and organic matter. Age/height figures of an average *E* hybrid plantation in this tract as read from a curve extrapolated beyond 5 years age from the data collected from a number of plantations (Ghosh, 1967) are given below.

Table 1

Age (yrs.)	1	2	3	4	5	6	7	8	9	10
Height (m	1.07	2.10	3.13	4.29	5.35	6.45	7.51	8.55	9.64	10.74

However, the average heights of 7.30 m and 12.46 m have also been obtained in 5 years in two different plantations of this zone as against the figure of 5.35 m above.

This paper presents the estimates of above ground biomass and nutrient uptake in a 10 year old *E.* hybrid plantation of Mouza Baribote, Hoomgarh Range, East Midnapore Forest Division as obtained by the Mean tree technique.

Locality factors

The forests of Southern West Bengal are found mostly on lateritic soil varying from felspathic clay of *murrum*, with gneiss and sandstone occurring at places. The tract has a

very hot summer where maximum temperature rises upto 47°C under shade with moderate winter of short duration. The mean annual rainfall varies from 900 mm to 1,400 mm, unevenly distributed though concentrated over a few months of the year during the monsoon. Delayed monsoon as well as long breaks during the rainy season are not uncommon, and continuous drought prevails from November to early May.

Materials and Methods

Eucalyptus hybrid plantation at Baribote was raised in the year 1964 over an area of 118 acres (47.75 ha) at a spacing of 8 ft. × 8 ft. (2 44 m × 2.44 m). Chemical fertilizer at the rate of 28 g per plant was applied at the time of mulching after the plants got established. The fertilizers applied were Ammonium sulphate, superphosphate and potassium muriate in the ratio of 3 N : 1 P_2O_5 : 3 K_2O. The plantation was thinned in the year 1968-69 whereby one-third of the crop was removed. It is presumed that before thinning the plantation had a full stocking of 1681 trees per hectare and after thinning it had 1120 trees per hectare and that it continued to remain constant thereafter (Ray, 1972). The plantation became due for felling in April, 1974, after completion of first rotation of 10 years.

It was at this juncture that the present study was undertaken and six sample trees of *E.* hybrid having the GBH of 36, 40, 44, 49, 55 and 59 cm representing a cross section of the plantation were felled for estimating the above ground biomass and nurient contents. The parameters of sample trees are shown in Table 2.

Table 2

Fresh and oven dry weights of sample trees (kg/tree)

Tree No.	GBH (cm)	Height (m)	Leaves		Branches	Wood	Bark	Total
1	59	18.35	Fresh wt.	11 500	18 000	196.000	44.000	269 500
			Oven dry wt.	5.750	10.170	113.000	17.380	146.300
2	55	15.90	Fresh wt.	11.475	23.500	162.200	38.800	235 975
			Oven dry wt.	5.316	14.100	90.610	15.520	125.546
3	49	16 60	Fresh wt.	6.975	8.000	124 100	26 900	165.975
			Oven dry wt.	3.325	4.910	64.940	9.330	82.505
4	44	16 00	Fresh wt.	5.200	11.000	89.850	2[illegible].150	134.200
			Oven dry wt.	2 440	5.940	51.820	10.840	71.040
5	40	15.85	Fresh wt.	3.700	9.500	78.190	16.060	107.450
			Oven dry wt.	2.230	5.650	42.430	5.540	55.850
6	36	13.00	Fresh wt.	4.700	8.000	52.540	15.960	81.200
			Oven dry wt.	2.130	4.030	31.700	6.170	44.030
Average sample tree	47	15.95	Fresh wt.	7.258	13.000	117.150	28.310	165 718
			Oven dry wt.	3.532	7.467	65.750	10.797	87.545

Fresh weights of all the tree components of sample trees were determined in the field by separating them into bole (wood and bark), branches, and leaves The bole portion of the sample trees was cut into 2 m long sections for convenience of weighing. Representative samples of all the plant parts were oven dried and analysed for ash, Ca, Mg, P, K and N by standard laboratory methods. No attempt was made to extract the root system of the sample trees as *E.* hybrid was expected to coppice three times without loss of vigour of stools before final felling.

Results and Discussion

Individual tree dimensions. This was an even aged plantation raised in the natural zone of sal with no other associate in the tree canopy. However, there was a wide variation in the GBH and heights of the trees, ranging from 36 to 59 cm and 13 to 18.35 m respectively. The difference in growth pattern in an even-aged plantation may be partly due to the genetical variation and partly to ecological or chance factors favouring certain seedlings in initial stages so that they grow rapidly during the early years to attain a more favourable position which influences tree form (Ovington and Madgwick, 1959).

Dry matter production. Fresh and dry weights of various components of the sample trees are indicated in Table 2 and the total above ground biomass as based on average of sample trees is given in Table 3. It will be observed that the total standing biomass at the end of the rotation is 98,052 kg/ha. The contribution of various tree components to the total standing biomass is : bole, 75.10% (73,640 kg/ha); bark, 12.33% (12,093 kg/ha); Branches, 8.53% (8,363 kg/ha) and leaves 4.03% (3,956 kg/ha). But as the plantation was thinned in 1968–69 whereby one-third of the crop (561 trees/ha) was removed, substantial amount of standing biomass must have been removed in thinning.

Age/height figures of an average *E.* hybrid plantation in this tract (Table 1) indicate that an average tree attains half the height in 5 years (5.35 m) as compared in 10 years (10.74 m). It may, therefore, be assumed that at the time of thinning, i.e., an age of 5 years, the Baribote plantation must have attained half of all the growth parameters as at the end of rotation, i.e., in 10 years. If so, 25% of the total standing biomass at the end of rotation i.e., 24,513 kg/ha was removed from the site when the crop was thinned after 5 years and 561 trees were felled. This amounts to the bole being 18,410 kg/ha, bark 3,023 kg/ha, branches 2,091 kg/ha and leaves 989 kg/ha. Thus the total above ground biomass produced during the entire first rotation comes to 1,22,565 **kg/ha** and the contribution of various tree components is of the order of bole 92,050 kg/ha; bark 15,116 kg/ha; branches 10,454 kg/ha and leaves 4,945 kg/ha. George (1977) reported the total above ground biomass of a 10 years old plantation of *E.* hybrid in East Dehra Dun Forest Division (U.P.) as 1,20,389 kg/ha and the contribution of various tree components is bole 82,804 kg/ha bark, 13,764 kg/ha, branches 18,874 kg/ha and leaves 4,947 kg/ha. This data compares well with the estimates drawn from an even-aged *E.* hybrid plantation on lateritic soil of West Bengal. In fact, Baribote plantation produced more of bole and less of branches as compared with the plantation of East Dehra Dun.

Table 3

Total above ground biomass

(oven dry weight kg/ha)

Mean tree technique

	Leaves	Branches	Wood	Bark	Total
Standing biomass at the end of rotation of 10 years (1120 trees/ha)					
	3956	8363	73640	12093	98052
	(4.03)	(8.53)	(75.10)	(12.33)	
Biomass removed by thinning after 5 years (561 trees/ha)					
	989	2091	18410	3023	24513
Total above ground biomass produced during the first rotation (1681 trees/ha)					
	4945	10454	92050	15116	122565

Note : Figures in brackets indicate percentage of the standing oven dry weight.

Nutrient uptake Nutrient content of an average sample tree as per cent on oven dry basis and kg/tree and total nutrient content (kg/ha) as determined by mean tree technique are presented in Table 4 and 5 It will be seen that of the total standing nutrient content (kg/ha) at the end of rotation Ca contributes the highest (698.88 kg) followed by N (292.32 kg), K (207.20 kg), Mg (77.28 kg) and P (26 88 kg), the total ash content being 2,205.28 kg/ha. As assumed earlier 25% of these total standing nutrient contents at the end of the rotation must have gone with thinning of 1/3rd of the crop after 5 years. This amounts to 174.72 kg of Ca, 73.08 kg of N, 51.80 kg of K, 19.32 kg of Mg and 6.72 kg of P, the ash contents being 551.32 kg/ha Thus the total nutrient uptake during the entire first rotation is Ca 873 60 kg, N 365 40 kg, K 259.00 kg, Mg 96.60 kg. P 33.60 kg and the total ash content 2,756.60 kg/ha. George (1977) indicated an uptake of 1,082 kg of Ca, 392 kg of N, 295 kg of K, 108 kg of Mg and 94 kg of P in an even-aged *E.* hybrid plantation of East Dehra Dun Forest Division which is to be on higher side to that of the Baribote plantation. There is a tremendous difference in the uptake of P in the two plantations. The difference in the nutrient uptake of the two plantations can be attributed due to the fact that the lateritic soils are inherently impoverished in mineral contents and organic matter.

Table 4

Nutrient content of an average sample tree

	Plant part	Ash	Ca	Mg	P	K	N
Per cent on oven dry basis	Leaves	5.749	1.357	0.308	0.087	0.910	1.787
	Branches	3.255	0.947	0.150	0.027	0.353	0.383
	Bole	0.637	0.210	0.023	0.023	0.108	0.190
	Bark	10.228	3.400	0.293	0.033	0.522	0.410
Kg/tree	Leaves	0.203	0.048	0.011	0.003	0.032	0.063
	Branches	0.243	0.071	0.011	0.002	0.026	0.029
	Bole	0.419	0.138	0.015	0.015	0.071	0.125
	Bark	1.104	0.367	0.032	0.004	0.056	0.044
	Total	1.969	0.624	0.069	0.024	0.185	0.261

Table 5

Total nutrient content (kg/ha) by mean tree technique

Plant part	Ash	Ca	Mg	P	K	N
Nutrient content of standing biomass at the end of rotation of 10 years (1120 tree/ha)						
Leaves	227.36	53.76	12.32	3.36	35.84	70.56
Branches	272.16	79.52	12.32	2.24	29.12	32.48
Bole	469.28	154.56	16.80	16.80	79.52	140.00
Bark	1236.48	411.04	35.84	4.48	62.72	49.28
Total	2205.28	698.88	77.28	26.88	207.20	292.32
Nutrient content removed by thinning after 5 years (561 trees/ha)						
	551.32	174.72	19.32	6.72	51.80	73.08
Total nutrient content uptake during the first rotation (1681 tree/ha)						
	2756.60	873.60	96.60	33.60	259.00	365.40

Eucalyptus hybrid (Mysore gum) seems to be well suited for this tract when grown with adequate manuring. From the growth rate of this species on average type of soil the crop at the end of first rotation can be expected to yield about 90 tonnes of usable wood per ha which should increase with better inputs and experience in raising these plantations. This species is also a good coppicer and expected to coppice three times on a rotation of 10 years without much mortality and loss of vigour of stools before final felling. *Eucalyptus* has been found suitable for several wood based industries and the tempo of its planting is gradually being stepped up. Since most of the units of wood based industries in West Bengal are situated in and around Calcutta the prospects of raising this species in the lateritic tract seem to be quite striking.

Acknowledgements

The invaluable help rendered by Shri B. Banerjee, Additional Divisional Forest Officer, East Midnapore Forest Division in conducting this study is gratefully acknowledged.

SUMMARY

Distribution of organic matter and plant nutrients in a 10 years old *Eucalyptus* hybrid plantation raised on lateritic soil in Mauza Baribote, Hoomgarh Range, East Midnapore Forest Division, West Bengal have been discussed. It seems that *Eucalyptus* hybrid is well suited for this tract when growth with adequate manuring. From the growth rate of this species on average type of soil the crop at the end of the first rotation can be expected to yield about 90 tonnes of usable wood per ha which should increase with better inputs and experience in raising these plantations

पश्चिम बंगाल की इष्टकिजीय (लेटराइटी) मृदा में लगे हुये संकर युकेलिप्टस रोपवन में
जेव पदार्थ और पोष्याहारों का वितरण

लेखक ए०सी० गुप्ता व डी०पी० रतूड़ी

सारांश

इस अभिपत्र में मौजा बारीबोटे, हूमगढ़ परिक्षेत्र, पूर्व मिदनापुर वन मण्डल, पश्चिम वंगाल में इष्टकिजीय (लेटराइटी) मृदा में लगे हुए संकर यूकेलिप्टस के दस वर्षीय रोपवन जैव पदार्थो और पादप पोष्याहारों के वितरण पर विचार विमर्श किया गया है। लगता यही है कि पर्याप्त खाद दे कर उगाने पर संकर युकेलिप्टस इस क्षेत्र के लिये बहुत अनुकूल है। औसत प्रकार की मृदा में इस वृक्ष जाति की वृद्धि दर से पहले आवर्तन की समाप्ति पर इससे प्रति हेक्टेयर लगभग 90 टन उपयोज्य काष्ठ फसल मिलने की आशा की जा सकती है जो इन रोपवनों को उगाने में धनराशी और अनुभव अधिक लगाने पर और भी अधिक बढ़ जानी चाहिये।

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TRIAL OF *EUCALYPTUS* F.R.I.-4 AND F.R.I.-5 ON DIFFERENT DOSES OF MANURE

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Introduction

Experiment plots 1 and 2 in Gamharia Research Centre were planted in the year 1978 at a spacing of 2 m × 2 m. The species is *Eucalyptus*, variety F.R.I.-4 & F.R.I.-5. The above two varieties were planted up in the year 1978 and three treatments of manuring were given to both the varieties.

Treatment 'A'

Consisted of initial doses of 7 gms of Urea and 14 gms of S.S.P. and it was treated as control plot and these fertiliser were applied in the year 1978 in the 1st year of planting at the time of planting.

Treatment 'B'

Consisted of the same dose of fertilisers as mentioned above applied in the year 1979 in the 1st weeding and hoeing.

Treatment 'C'

Consisted of the above dose of fertilisers but applied in the 2nd year twice one in 1st weeding and hoeing and second in the 2nd weeding and hoeing.

Design of Experimental Plot No. 1 & Plot No. 2.

Seven replications of three treatments in randomised block design Spacing 2 m × 2 m.

I	II	III	IV	V	VI	VII
B	A	C	C	A	B	B
A	C	A	B	B	A	C
C	B	B	A	C	C	A

Each block contained ten plants only

Measurements

Based on measurements recorded in Dec, '82 results are analysed below.

Discussion

In treatment No. 'C' that is 07 gm of Urea and 14 gms of Single Super Phosphate applied initially in the planting year 1978 and again the same dose applied with the 1st weeding and hoeing and again the same dose applied with 2nd weeding and hoeing 3 times manuring. The growth obtained is average height of 8.32 m and average diameter of 6.6 cm with the mortality of 11.43%. Even with initial dose as applied in the 1st year i.e 7 gms Urea and 14 gms Single Super Phosphate. Treatment 'A' F.R.I.–5 achieved the average height of 8 m and average. diameter of 6.5 cm mortality 7.14% against the treatments in F.R.I.–4 i e. Triple manuring which gave an average height of 7.5 m and average diameter 6.4 cm with casuality 11.43%. Thus the variety F.R.I. 5 has proved better than F.R.I.–4 at Gamharia Research Centre.

Now considering the mortality in F.R.I –5 alone the casualty in treatment 'C' (Triple manuring) and treatment 'A' (Single manuring in 1st year) figure for casualty in treatment 'C' is 11.43% in treatment 'A' is 7.14% thus there is a difference of .31% as for as survival of plants are concerned thus 107 No. of plants per hectare survived more in treatment 'A' than 'C'. Now due to treatment 'C' the extra height growth obtained is only 0.32 m and in diameter growth it is only 0.1 cm.

Statistical calculation of Eucalyptus F.R.I.–4

	Mean ht. (m)	S.D.	Valume (m^3)	mean Dia (cm)	S.D.
Replication A —	7.48	1.04	0.00893	6.4	0.87
Replication B —	7.13	0.61	0.00764	6.15	0 54
Replication C —	7.51	1.08	0 00893	6.4	0.92

Vol calculation is done on the basis of the regression equation $\sqrt{V} = -0.0868 + 2.8335 D$.

Where V is the volume in m^3 and D is the mean diameter in cm taken from the breast height (d.b.h)

From the above figures the following results are obtained Replication B i.e., 7 gms of Urea and 24 gms of S.S P. applied initially in the first year and again applied in the following year of planting i.e. 7 gms of Urea and 14 gms of S.S.P. total 14 gms of Urea + 28 gms S.S.P. has been applied partly in the planting year and partly in the following year of planting. Since the deviation from mean is 0.61 in height growth and 0.54 in the diameter growth is the lowest in all the replications.

Statistical calculation of Eucalyptus F.R.I.–5

	Mean ht (m)	S.D.	Av. Volume /plant (m^3)	Mean dia (cm)	S.D
Replication A	7.99	0.99	0.00932	6.47	0.74
Replication B	7.61	1.03	0.00740	6.10	0.77
Replication C	8.32	1.15	0.00993	6.58	1.21

In F.R.I.–5 the Replication 'A' which consisted of manuring @ 7 gms of Urea + 14 gms of S.S.P. in the planting year has done best as the deviation from the mean is only 0.99 in the height growth and 0.74 mean deviation in the diameter growth which is lowest among the three treatments applied

Comparison between F.R.I.–4 and F.R I.–5

Thus from the above calculation it is seen that F.R.I–5 is comparatively better than F.R.I–4 due to the reasons that the mean deviation is lowest in F.R.I.–5 both in height and diameter and only one time manure is applied at the time of planting economising in cost of manure and labour.

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FERTILIZATION IN *EUCALYPTUS GRANDIS* ON SEVERELY TRUNCATED SOIL. I : GROWTH STUDIES

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Introduction

Repeated attempts to reclaim the extensive grasslands in Kulamavu and Idukki areas of Nagarampara Range, Kottayam Division, Kerala did not give satisfactory results. Survey and field studies conducted by the Eucalyptus Fungus Investigation Unit of the Hindustan Paper Corporation Limited (A Government of India Enterprise) established that the pests and diseases are not the major factors for the decline of *Eucalyptus* in this area. Subsequently they approached the Southern Regional Centre of the Forest Soil-cum-Vegetation Survey, at Coimbatore to help in solving the problem.

Based on initial survey and laboratory analysis of soil samples, it was felt that the soil is deficient in primary nutrients like Nitrogen and phosphorus which may be the limiting factor for the poor growth of *Eucalyptus grandis* at Kulamavu and Iddukki areas. Therefore, the present experiment was laid out to know the optimum dose of N and P fertilizers. It was also decided to workout the economics of different fertilizer application to workout relative economic effectiveness of various treatments.

Materials and Methods

The experiment was conducted at Minmutti which is about 9 km from Idukki dam on Idukki-Kottayam road (Latitude 9°50′ N and Longitude 76°56′ E). The area receives about 4125 mm of rainfall per year with an average temperature of 21°C, and was under grassland before start of the experiment. Experimental site was situated at 20-30% slope with severe erosion. Severely truncated soil is a member of sandy skeletal, mixed, isothermic family of Lithic Dystropepts developed from charnockites rich in biotite mica with occassional gneissic bunds at an altitude of 800 m above msl. Table 1 furnishes physical and chemical properties of the soil.

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Table 1

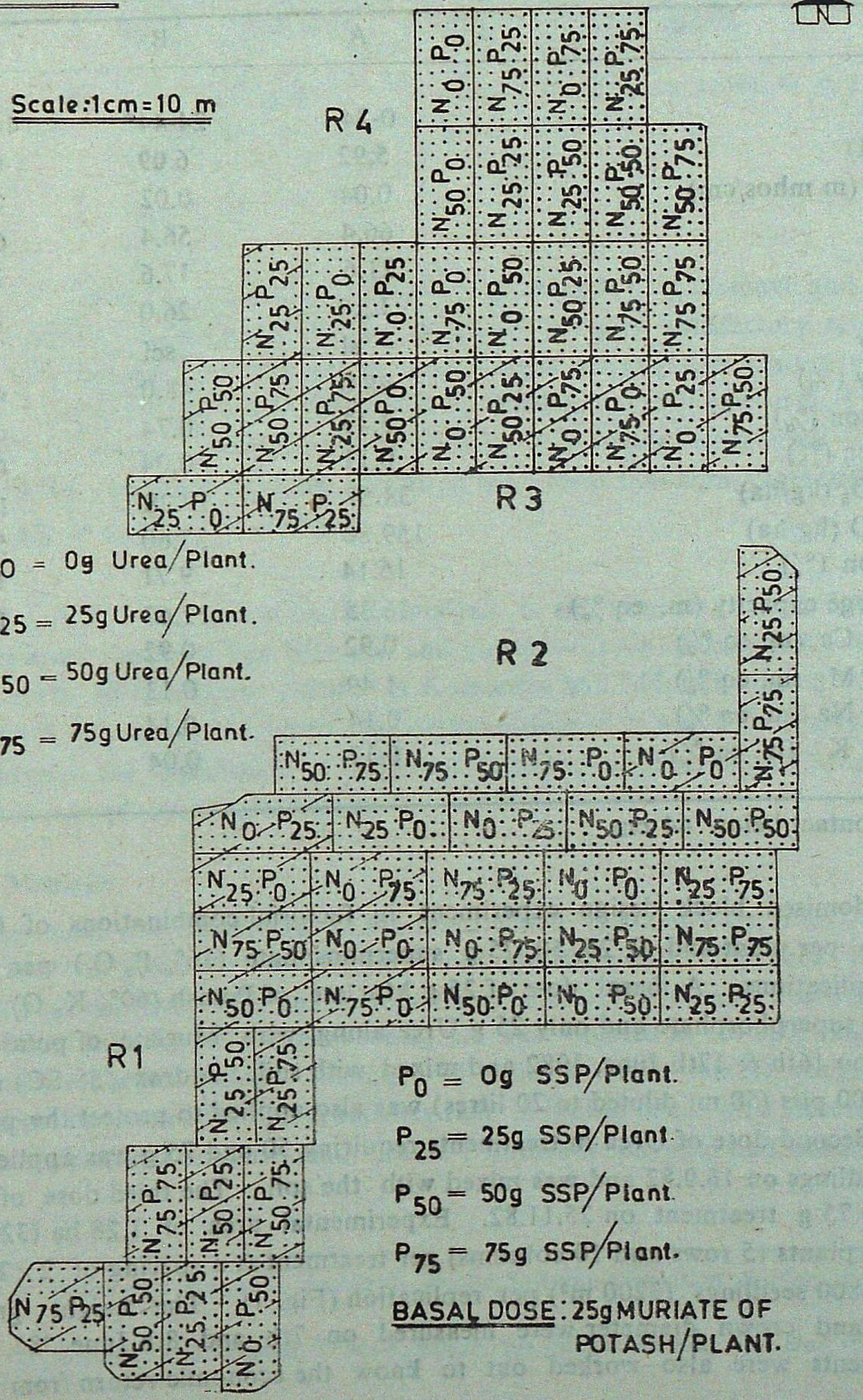
Physico-chemical properties of soils at Minmutti Nagrarmpara Range, Kerala

	A	B	C
Depth (cms)	0-24	24-44*	44-96
Reaction (pH)	5.92	6.09	6.00
Conductivity (m mhos/cm)	0.04	0.02	0.02
Sand (%)	66.4	56.4	64.4
Silt (%)	21.6	17.6	19.6
Clay (%)	12.0	26.0	16.0
Textural class	sl	scl	sl
Field capacity (%)	48.0	48.0	48.0
Organic Carbon (%)	3.43	0.74	0.94
Total Nitrogen (%)	0.11	0.04	0.04
Available P_2O_5 (kg/ha)	38.57	19.28	11.59
Available K_2O (kg/ha)	159.80	37.60	56.40
Base saturation (%)	16.14	9.71	11.44
Cation exchange capacity (m. eq %)	16.85	12.67	12.67
Exchangeable Ca (m. eq %)	0.92	0.92	1.23
Exchangeable Mg (m. eq %)	1 49	0.13	t
Exchangeable Na (m. eq %)	0.14	0.14	0.16
Exchangeable K (m. eq %)	0 17	0.04	0.06

* Paralithic contact below 44 cm.

A randomised block design experiment in factorial combinations of 0, 25, 50, 75 g Urea (48% N) per plant and 0, 25, 50, 75 g superphosphate (16% P_2O_5) per plant was laid out with 4 replications. A basal dose of 25 g Muriate of Potash (60% K_2O) per plant was applied. All superphosphate and only 25 g Urea along with Muriate of potash was applied to 15 cm³ pit on 16th & 17th June, 1982 and mixed with soil. Aldrax (30 EC) at the rate of 20 litres per 100 pits (50 ml diluted to 20 litres) was also applied to protect the plant from soil born insects. Second dose of Urea in treatments requiring 50 and 75 g was applied as topdress around the seedlings on 16.9.82 and was mixed with the soil. The third dose of 25 g of Urea was applied to 75 g treatment on 25.11.82. Experimental area of 1.28 ha (3200 seedlings) consisted of 50 plants (5 rows and 10 columns) per treatment at a spacing of 2×2 m² (200 m²) with a total of 800 seedlings (3200 m²) per replication (Fig. 1). The height growth, collar circumference and crown diameter were measured on 7th and 8th June '83. The cost of various treatments were also worked out to know the economic return from the fertilizers applied.

FIGURE 1. LAY OUT PLAN OF FERTILIZER EXPERIMENT ON E. GRANDIS AT MINMUTTI, NAGARAMPARA RANGE, KERALA.



Relative treatment effectiveness (RTE) and Relative economic effectiveness (REE) was calculated as :

$$RTE = 100 \times \frac{\text{Volume yield in treatment} - \text{Volume yield in control}}{\text{Volume yield in control}}$$

$$REE = RTE \times \frac{\text{Cost in Control}}{\text{Cost due to treatment}}$$

Results and Discussion

The growth of *E. grandis* (height, collar circumference and volume) after one year of growth as shown in Table 2 was significantly superior either due to Nitrogen or phosphorus treatment alone or in combination. Added dose of nitrogen continued to increase the height growth significantly till 75 g of Urea per plant whereas effect of super phosphate without N application was deterimental to plant growth. Thus the maximum height of 280 cm was recorded in treatment $N_{75}P_{50}$ which was two times more than Control (140 cm). Treatment $N_{75}P_{50}$ was statistically at par with $N_{50}P_{50}$ and $N_{75}P_{75}$ treatments at 1% level of significance.

Interestingly phosphorus had no significant effect on collar circumference of the *E. grandis* plants. On the other hand application of Urea was highly significant upto 50 g/plant after which it remained almost constant. Though, the maximum collar circumference was recorded in $N_{75}P_{75}$ treatment, the N $\times$ P interaction effect was statistically not significant. Similar to tree height collar circumference also decreased with the application of superphosphate without any nitrogen application.

Crown diameter was also significantly affected due to N and P application either alone or in combined application. Similar to tree height, crown diameter also continued to increase with increasing doses of urea application whereas superphosphate application beyond 30 g/seedling did not increase the crown diameter significantly. The highest diameter was recorded in treatment $N_{75}P_{75}$ (208.8 cm) whereas the crown diameter of the control treatment was 74.3 cm. Further, crown diameter at $N_{75}P_{75}$ treatment was statistically at par with $N_{75}P_{50}$ and $N_{50}P_{75}$ treatments at 1% level of significance.

The enhancement in the volume of *E. grandis* plants calculated on the basis of tree height and collar circumference were highly significant due to both N and P applications either alone or in combination. The maximum volume of *E. grandis* of 4.12 m^3/ha was recorded in treatment $N_{75}P_{75}$ whereas the control had a volume of only 0.82 m^3/ha. The volume of *E. grandis* decrease at N_{75} treatment when no P was applied whereas it continued to increase upto maximum dose of N when P was applied, whereas application of P decreased the volume when applied without N application. The volume growth of *E grandis* after 1 year in treatment $N_{75}P_{75}$ was statistically on per with $N_{50}P_{75}$, $N_{75}P_{25}$ and $N_{75}P_{50}$ treatments at 1% level of significance.

Table 2

Tree height, collar circumference, crown diameter and volume of E. grandis due to fertilization.

Treaments	P_0	P_{25}	P_{50}	P_{75}	Mean	L.S.D. at 1%	
			Tree height (cm)				
N_0	140	127	139	134	135	—	—
N_{25}	159	198	219	213	197	N	23.6
N_{50}	200	216	249	236	225	P	23.6
N_{75}	203	244	280	268	249	N × P	47 3
Mean	176	196	222	213	—	—	—
			Collar circumference (cm)				
N_0	8.83	6.37	7.50	8.57	7.82	—	—
N_{25}	8.67	12.12	12.40	12.32	11.38	N	2.74
N_{50}	13.02	12.27	14.30	14.32	13.48	P	N.S
N_{75}	10.42	13.25	13.92	14.53	13.03	N × P	N S
Mean	10.24	11.00	12.03	12.44	—	—	
			Crown diameter (cm)				
N_0	74.3	77.5	106.7	103.8	90.6	—	—
N_{25}	101.3	152.5	153.3	133.3	134.6	N	31.0
N_{50}	167.7	138.8	159.3	175 0	160.2	P	31.0
N_{75}	164.5	157.5	196.0	208.8	181.7	N × P	N.S
Mean	127.0	131.6	153.8	154.7	—	—	—
			Volume (m^3/ha)				
N_0	0 82	0.37	0.57	0.74	2.50	—	—
N_{25}	1.10	2.10	2.15	2 52	7.87	N	0.65
N_{50}	2.12	2.49	3.56	3.58	11.75	P	0.65
N_{75}	1.67	3.33	3.80	4.12	12.92	N × P	1.29
Mean	5.71	8.29	10.08	10.96	—	—	—

Note : N=Urea (48 % N)

P=Superphosphate (16% P_2O_5)

Table 3

Cost of planting E grandis at Minmutti, Nagarampara Range, Kerala

Items		Cost of planting	
		per ha (Rupees)	per plant (Paise)
(a) *Pre-Planting Operations** :			
Raising seedlings	...	809.34	32.4
Clear knife weeding in April '82	...	212.74	8.5
Skining of the entire area in May '82	...	638.25	25.5
Collection of sticks for alignment	...	86.10	3.4
Cost of alignment	...	155.90	6.2
Collection of pegs	...	430.50	17.2
Labour cost for lay-out	...	172.20	6.9
Pitting	...	228.64	9.1
Transport of seedlings	...	130.69	5.2
Cost of planting	...	100.93	4.1
Mulching	...	176.98	7.1
Total of preplanting operations	...	3142.27	125.6
(b) *Post-Planting Operations** ;			
Knife weeding in October '82	...	106.38	4.3
Spade weeding in October '82	...	255.20	10.2
Knife weeding in January '83	...	106.38	4.3
Spade weeding in January '83	...	255.20	10.2
Total of post planting operations	...	723.16	9.0
(c) *Cost of Applying Fertilizer**	...	225.00	9 0
(d) *Cost of Materials* :			
Aldrax (30 E.C.)	...	87.50	3.5
Muriate of Potash @ 25 g per plant	...	83.00	3.3
Urea			
@ 25 g per plant	...	147.00	5.9
@ 50 g per plant	...	294 00	11.8
© 75 g per plant	...	441.00	17.6
Superphosphate			
@ 25 g/plant	...	58 25	2.3
@ 50 g/plant	...	116.50	4 7
@ 75 g/plant	...	174.75	7.0

* Includes variable clearness allowance.

Table 3 gives detailed breakup of cost per hectare in raising the plantation. It may be seen from Table 4 that total cost/plant does increase with various treatments and are about 32% more in the N_{75} P_{75} treatment than in control. However, considering the relative treatment effectiveness (RTE), and relative economic effectiveness (REE), treatment $N_{75}P_{75}$ continues to be the most effective treatment with regards to economics as well as volume yield, (Fig. 2). The treatment $N_{75}P_{75}$ is followed by treatment $N_{75}P_{50}$ and $N_{50}P_{75}$ treatments.

Table 4

Cost (in Rupees) of planting E. grandis due to various treatments at Minmutti, Nagarampara Range, Kerala

Treatment	Cost per plant			Cost per hectare
	Planting*	Fertilizer**	Total	
N_0O_0	1.613	—	1.613	4032.50
N_0O_{25}	1.613	0.113	1.726	4315.00
N_0P_{50}	1.613	0.137	1.750	4375.00
N_0P_{75}	1.613	0.160	1.773	4432.50
$N_{25}P_0$	1.613	0.149	1.762	4405.00
$N_{25}P_{25}$	1.613	0.172	1.785	4462.50
$N_{25}P_{50}$	1.613	0.195	1.808	4250 00
$N_{25}P_{75}$	1.613	0.218	1.831	4577.50
$N_{50}P_0$	1.613	0.298	1.911	4777.50
$N_{50}P_{25}$	1.613	0.321	1.934	4835.00
$N_{50}P_{50}$	1.613	0.344	1.957	4892.50
$N_{50}P_{75}$	1.613	0.367	1.980	4950.00
$N_{50}P_0$	1.613	0.446	2.059	5147.50
$N_{75}P_{25}$	1.613	0.469	2.082	5205.00
$N_{75}P_{50}$	1.613	0.492	2.105	5262.50
$N_{75}P_{75}$	1.613	0.515	2.128	5320.00

* Including cost of insecticide and muriate of potash.

** Including cost of application.

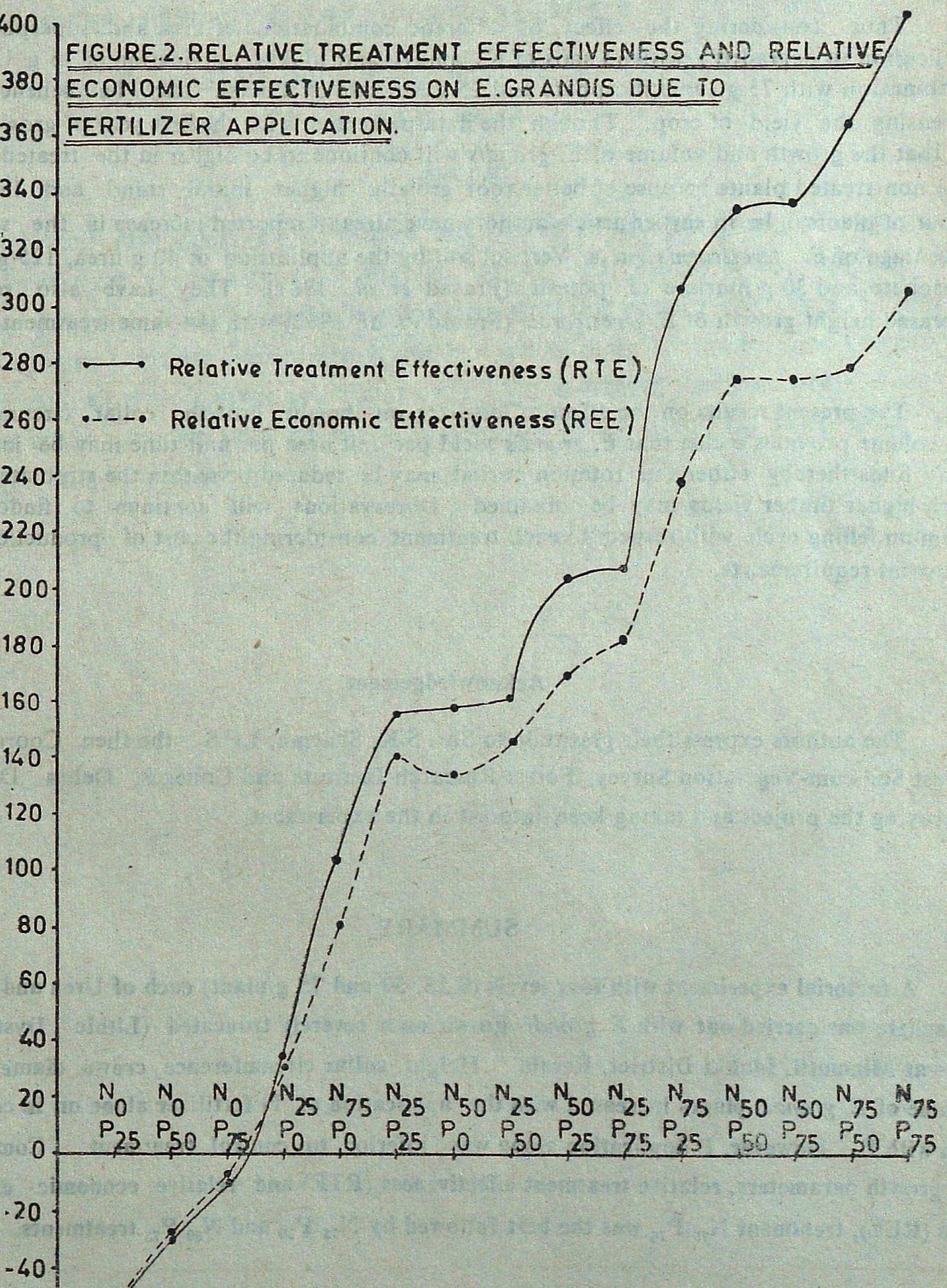


FIGURE.2. RELATIVE TREATMENT EFFECTIVENESS AND RELATIVE ECONOMIC EFFECTIVENESS ON E. GRANDIS DUE TO FERTILIZER APPLICATION.

Thus considering the effect of different combinations of urea and superphosphate application in degraded grassland soils of Kulamavu and Idukki, application of 75 g Urea in combination with 75 g superphosphate and 25 g Muriate of Potash may be beneficial for increasing the yield of crop. Though, the data presented is for the first year of growth, it is felt that the growth and volume of *E. grandis* will continue to be higher in the treated plants than non-treated plants because of better root growth, higher initial stand and increased vigour of plants. In an earlier article authors have already reported increase in the survival percentage of *E. tereticornis* in a Vertisol soil by the application of 40 g urea, 125 g superphosphate and 30 g muriate of potash (Prasad *et. al.* 1981). They have also reported increased height growth of *E. tereticornis* (Prasad *et. al.* 1982) with the same treatment.

The present results on the effect of fertilizer on height growth, collar circumference and volume provides a clue that *E. grandis* yield per unit area per unit time may be increased many folds thereby either the rotation period may be reduced or within the stipulated time, much higher timber yields may be obtained Observations will continue to findout the optimum felling cycle with respect to each treatment considering the cost of production and industrial requirements.

Acknowledgement

The authors express their gratitude to Shri S.K. Sharma, I.F.S , the then Coordinator, Forest Soil-cum-Vegetation Survey, Forest Research Institute and Colleges, Dehra Dun for approving the project and taking keen interest in the experiment.

SUMMARY

A factorial experiment with four levels (0 25, 50 and 75 g/plant) each of Urea and Superphosphate was carried out with *E. grandis* grown on a severely truncated (Lithic Dystropept) soils at Minmutti, Idukki District, Kerala. Height, collar circumference, crown diameter and volume of *E. grandis* plants increased with the application of N fertilizer alone or in combination with P. However, P application alone was inferior to control treatment. Considering the growth parameters, relative treatment effectiveness (RTE) and relative economic effectiveness (REE), treatment N_{75} P_{75} was the best followed by N_{75} P_{50} and N_{50} P_{75} treatments.

अत्यधिक व्याहृसित मृदाओं में युकेलिप्टस ग्रांडिस का उर्वरीकरण I—वृद्धि का अध्ययन

लेखक के०जी० प्रसाद, दिनेश कुमार, टी०जे० चन्द्रशेखरन नायर, एस० मोहन, जे० माधव नायर
व ए०डी० देव

सारांश

मिनमट्टी, जिला इडुक्की, केरल में अत्यधिक व्याहृसित (लिथिक लाइस्ट्रोपेप्ट) मृदाओं में उगाए जा रहे यु० ग्रांडिस में यूरिया और सुपरफास्फेट में प्रत्येक के चार स्तर (0. 25, 50, व 75, ग्राम/पादप) लेकर एकादिहत संपरीक्षण किया गया। युकेलिप्टस ग्रांडिस पादपों की ऊंचाई, मूलसन्धि पर परिधि, शीर्ष व्यास और आयतन नाइट्रोजन मात्र अथवा उसे फास्फोरस के साथ मिला कर देने से बढ़े। तथापि, मात्र फास्फोरस देना मियामक पादपों की तुलना में घटिया उपचार पाया गया। वृद्धि के परिमापों, आपेक्षिक उपचार दक्षता और आपेक्षिक आर्थिक दक्षता पर ध्यान देते हुए नाइ75 फा75 सबसे अच्छा उपचार रहा जिसके पश्चात् नाइ75 फा50 और नाइ50 फा75 उपचार रहे।

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FERTILIZATION IN *EUCALYPTUS GRANDIS* ON SEVERELY TRUNCATED SOIL II : BIOMASS PRODUCTION

K.G. PRASAD, G.N. GUPTA, S.B. SINGH, S. MOHAN, J. MADHAVAN NAIR AND A.D. DEO

With increasing pressure on land and growing fuel, fodder and industrial (wood based) needs and also with increasing urgency to save deteriorating environment, tree plantation on marginal and sub-marginal lands is assuming greater significance. Plant performance on these marginal soils is extremely poor for want of appropriate soil management practices and proper fertilizer use. At present our knowledge pertaining to quantity and methods of various fertilizer application in *Eucalyptus* is limited (Hussain and Thiagarajan, 1966; Kaul *et al.* 1966 a, b; Prasad *et al.* 1981, 1983 a, b; and Sinha, 1970).

Therefore, present investigation was undertaken to findout optimum fertilizer dose in *Eucalyptus grandis* on a severely truncated soil, common in the grasslands occurring around Idukki reservoir, Kerala, which is proposed to be a source of pulp wood for the newsprint division of Hindustan Paper Corporation Limited, Kottayam.

Experimental

The experiment is being carried out at Minmutti, Nagarampara Forest Range, Kottayam Division of Kerala. The experimental site is situated at an altitude of 800 m having 4125 mm of annual rainfall and 21°C average temperature. This severely truncated grassland soil belongs to Lithic Dystropepts. Important soil properties and various operations are furnished in the companion paper (Prasad *et al.* 1983 b). Experiment consists of 16 treatments in a factorial combination comprising of four levels of nitrogen (0, 25, 50 and 75 g urea/tree) and four levels of phosphorus (0, 25, 20 and 75 g superphosphate/tree). Basal dressing of 25 g muriate of potash per tree was given to the treatments. All fertilizer materials were mixed with soil before transplanting *E. grandis* seedlings except urea which when exceeded 25 g was top dressed in split doses of 25 g each at intervals of 3 months. Each treatment was replicated four times in a randomised block design.

After one year of transplanting one representative tree was harvested from all the plots. Fresh weight of whole tree above the ground and dry weight of leaves, twigs, stem and roots were recorded.

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Results

Fresh above ground biomass. Increasing levels of nitrogen and phosphorus applications significantly increased above ground biomass yield (fresh weight) of one year old *E. grandis* (Table 1). While increase due to superphosphate addition was not observed beyond 50 g/tree, application of nitrogen continued to enhance fresh weight upto its maximum dose. Influence of nitrogen was more conspicuous than phosphorus for the former when added at the rate of 75 g urea/tree, increased fresh weight from 0.32 to 3.77 kg (11.8 times) per tree whereas with 50 g superphosphate, the increase was only 1.8 times (1.47 to 2.62 kg per tree). Interaction of nitrogen and phosphorus was highly significant and synergistic, the intensity of which is evident from the fact that while $N_{75}P_{75}$ spured biomass production 15 fold (0.30 in control to 4.83 kg/tree), treatment $N_{75}P_0$ could increase fresh weight only by 7.5 fold (2.25 kg/tree). The N_0P_{75} treatment remained statistically non-significant in its effect.

Table 1

Effect on N and P application on fresh above ground biomass (kg/tree) of E. grandis

	P_0	P_{25}	P_{50}	P_{75}	Mean	C.D. at 5%	
N_0	0.30	0.29	0.30	0.40	0.32	—	
N_{25}	1.00	1.67	2.00	1.87	1.63	N	0.48
N_{60}	2.33	2 50	3.50	3.17	2.88	P	0 48
N_{75}	2.25	3.33	4.67	4.83	3.77	N×P	0.95
Mean	1.47	1 95	2.62	2.56	—	—	

Dry above ground biomass. While increasing level of urea resulted in significantly higher dry weight of foliage, twigs and stem, superphosphate was beneficial only at 50 g/tree level (Tables 2, 3, 4) Addition of 75 g urea/tree enhanced foliage weight from 96.85 to 488.08 g/tree (5 fold) twig weight from 55.65 to 448.8 g/tree (8 fold) and stem weight from 57.6 to 423.7 g/tree (7.4 fold). On the other hand, 50 g superphosphate/tree increased dry weight of foliage 1.5 times (231.7 to 337.68 g/tree), twigs 1.8 times (178 58 to 317.93 g/tree) and stem 1.94 times (161.65 to 313.3 g/tree). Combined, application of nitrogen and phosphorus showed a highly synergistic influence and was statistically significant. When compared with dry weight values in control, $N_{75}P_{75}$ treatment caused 9.4 fold increase (72.8 to 682 3 g/tree) in foliage, 14 6 fold (45.8 to 668.1 g/tree) in twigs and 11 8 fold (52 4 to 617 5 g/tree in stem. Application of superphosphate alone (N_0P_{50}) was found to show marginal effect on dry weight of foliage (1 5 times), twigs (1 5 time) and stem (1 3 time) On the other hand, urea alone ($N_{50}P_0$) treatment caused 4 0 times increase in foliage, 5.5 times in twigs and 4.5 times in stem beyond which increase in biomass was not statistically significant.

Table 2

Effect of N and P application on dry weight of E. grandis leaves (g/tree)

	P_0	P_{25}	P_{50}	P_{75}	Mean	C.D. at 5%	
N_0	72.8 (0.43)	78 9 (0.44)	108.8 (0.44)	126.9 (0.52)	96 9	—	
N_{25}	205.5 (0.43)	248.4 (0.38)	224.5 (0.30)	225.8 (0.32)	226.1	N	69.4
N_{50}	303.6 (0.38)	327.0 (0.36)	371.1 (0.32)	425.0 (0.33)	356.7	P	69.4
N_{75}	345.5 (0.41)	387.5 (0.37)	537.5 (0.34)	682.3 (0.35)	488.1	N×P	N.S.
Mean	231.7	260.3	337.7	365.0	—	—	

Data in parenthesis indicate ratio of dry weight of leaves to above ground biomass

Table 3

Effect of N and P application on dry weight of E. grandis twigs (g/tree)

	P_0	P_{25}	P_{50}	P_{75}	Mean	C.D. at 5%	
N_0	45.8 (0.27)	48.4 (0.27)	69.3 (0.28)	59.1 (0.24)	55 7	—	
N_{25}	139.6 (0.30)	201.8 (0.31)	263.4 (0.35)	229.8 (0.33)	208.7	N	62.7
N_{50}	256.4 (0.32)	290.1 (0.32)	423.0 (0.36)	418.3 (0.33)	346.0	P	62.7
N_{75}	272.5 (0.32)	338.6 (0.32)	516.0 (0.33)	668.1 (0.34)	448.80	N×P	125.4
Mean	178.6	219.7	317.9	342.8	—	—	

Data in parenthesis indicate ratio of dry weight of twigs to above ground biomass.

Table 4

Effect of N and P application on dry weight of E. grandis stem (g/tree)

	P_0	P_{25}	P_{50}	P_{75}	Mean	C.D. at 5%
N_0	52.4 (0.31)*	54.1 (0.30)	67.5 (0.28)	56 4 (0.23)	57.4	—
N_{25}	128 9 (0.27)	198.8 (0.31)	270.8 (0.36)	245.9 (0.35)	211.1	N 72.8
N_{50}	238.8 (0.30)	290.1 (0.32)	382.6 (0 33)	438.3 (0.34)	337.5	P 72.8
N_{75}	226.5 (0 27)	318.5 (0.31)	532.3 (0.34)	617.5 (0 31)	423.7	N×P 145 5
Mean	161.7	215 4	313.3	339.5	—	—

Data in parenthesis indicate ratio of dry weight of stem to above ground biomass.

Application of nitrogen as well as phosphorus increased total dry biomass production of one year old *E. grandis* (Table 5). Stepwise increase in nitrogen dose resulted in significantly higher dry matter production. Phosphorus effect was significantly higher only at level of 50 g superphosphate/tree The quantum of biomass production was as high as 6.5 fold (210.1 to 1360.6 g/tree) due to 75 g urea/tree application and only 1.6 fold (572.1 to 941.7 g/tree) owing to 50 g superphosphate/tree application beyond which there was no significant change. Combined application of urea and superphosphate was highly significant and synergistic. Combined application of urea and superphosphate was significant in increasing yield at all levels and maximum biomass yield was recorded in $N_{75}P_{75}$ treatment which was as much as 11.5 fold (1967.9 g/tree) as compared to control (171.1 g/tree).

Table 5

Effect of N and P application on dry above ground biomass (g/tree) of E. grandis

	P_0	P_{25}	P_{50}	P_{75}	Mean	C D. at 5%
N_0	171.1 (0.57)*	181.4 (0.63)	245.6 (0.82)	242.4 (0.61)	210.1	—
N_{25}	474.0 (0.47)	649.0 (0.39)	758.7 (0.38)	701.5 (0.38)	645.8	N 180
N_{50}	798.8 (0.34)	907.2 (0.36)	1176.7 (0.33)	1277.6 (0.40)	1041.1	P 180
N_{75}	844.5 (0.38)	1044.1 (0.31)	1585.8 (0.34)	1967.9 (0.41)	1360 6	N×P 370
Mean	572.1	695.4	941.7	1047.4	—	—

*Values in parenthesis indicate ratio of dry above ground biomass to fresh above ground biomass.

Dry below ground biomass. Dry below ground biomass (roots) increased with increasing levels of nitrogen and phosphorus (Table 6). Quantum of increase on an average was 6.8 and 3.7 folds due to highest dose of urea and superphosphate application; respectively. Similar to abave ground biomass, application of urea alongwith superphosphate had highly significant synergistic influence on dry weight of ropts. Dry weight of roots increased 20 times (437.5 g/tree) as compared to 22.5 g/tree in control due to $N_{75}P_{75}$ treatment whereas root dry weight increased only 6.0 folds (97.5 g/tree) due to $N_{50}P_0$ treatment and 3.0 fold (68.0 g/tree) due to $N_{50}P_{50}$ treatment beyond which below ground biomass decreased.

Table 6

Effect N and P application on dry below ground biomass (g/tree) of E. grandis

	P_0	P_{25}	P_{50}	P_{75}	Mean
N_0	22.5	35.5	6 .0	35.5	40.4
N_{25}	27.5	149.0	206.0	224.5	151.8
N_{50}	135.0	155.0	244.5	341.0	218.9
N_{75}	97.5	213.0	349.5	437.5	274.4
Mean	70.6	138.1	217 0	259.6	

Discussion

On perusal of Table 2, 3 and 4 it is evident that ratio of dry weight of various tree components to the total dry weight of tree gives approximate estimate of their relative response to fertilizer application. Relatively better influence of N and P fertilizers on stem and twigs is evident from increasing stem/tree and twigs/tree ratio vis-a-vis foliage/tree ratio which remaind unchanged.

Another interesting observation was recorded that the succulance of plant as indicated by the ratio of dry weight to fresh weight increased by the application of N and P fertilizers alone or in combination (Table 5).

Fertilizer use efficiency. The data on total above ground biomass yield was used to calculate fertilizer use efficiency (FUE) by the formula :

Fertilizer use efficiency = $(E_F - E_O) \times 100/F$

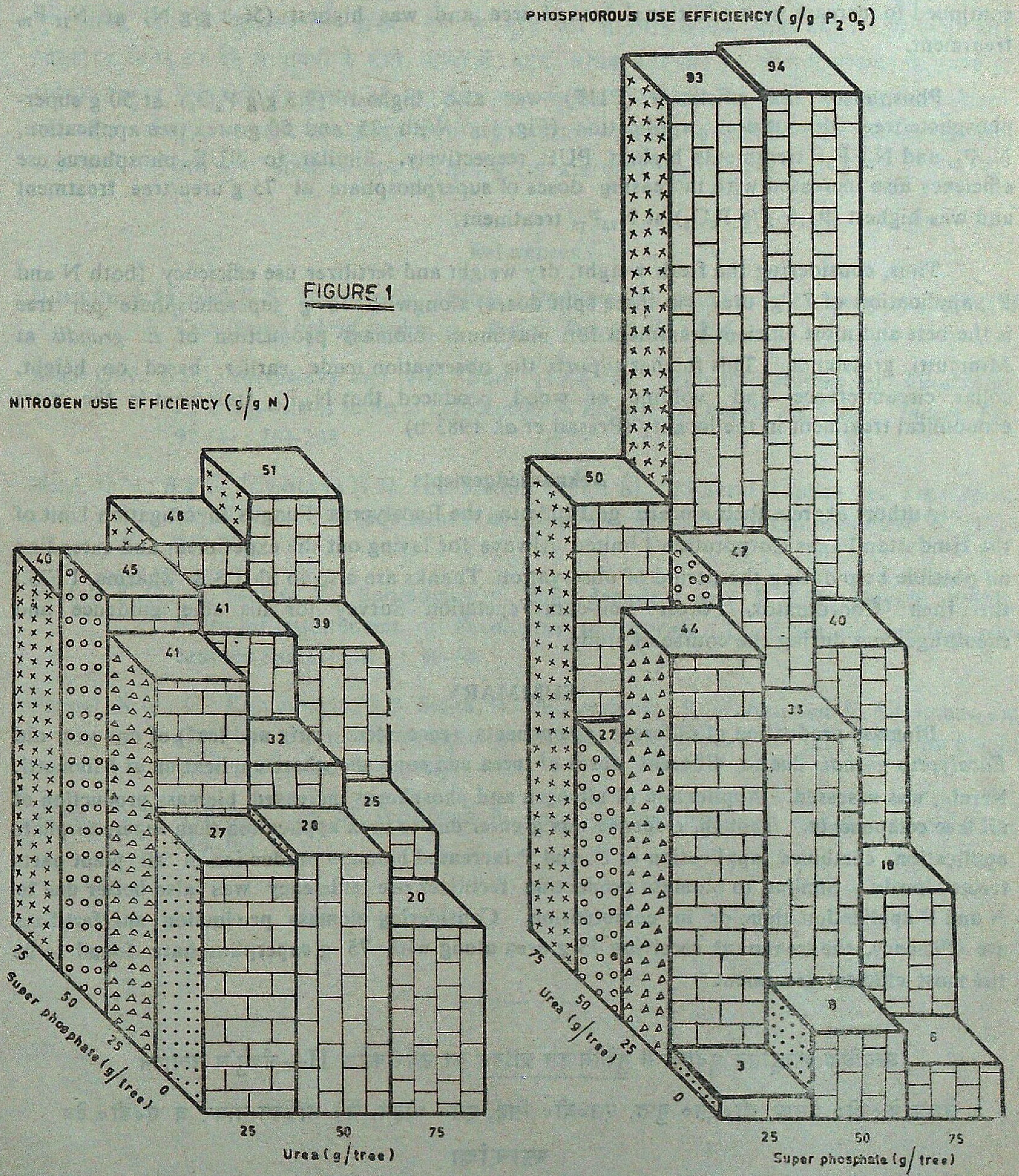
Where; E_F = Dry above ground biomass in fertilized plants

E_O = Dry above ground biomass in unfertilized plants

and F = Total fertilizer applied

Nitrogen use efficiency (NUE) was maximum (27.6 g/g N) with 50 g urea/tree when added alone (Fig. 1). The $N_{75}P_0$ treatment registered decrease in nitrogen use efficiency. Addition of 25 and 50 g superphosphate/tree increased NUE and was hiegest at 25 g urea/tree

FIGURE 1



FERTILIZER USE EFFICIENCY OF N AND P IN E. GRANDIS

application. Higher NUE was observed at 75 g superphosphate/tree application and continued to increase with additional dose of urea and was highest (56.8 g/g N) at $N_{75}P_{75}$ treatment.

Phosphorus use efficiency (PUE) was also highest (9.3 g/g P_2O_5) at 50 g superphosphate/tree without urea application (Fig. 1). With 25 and 50 g urea/tree application, $N_{25}P_{25}$ and $N_{50}P_{50}$ treatments highest PUE; respectively. Similar to NUE, phosphorus use efficiency also increased with increasing doses of superphosphate at 75 g urea/tree treatment and was highest (93.6 g/g P_2O_5) at $N_{75}P_{75}$ treatment.

Thus, considering the fresh weight, dry weight and fertilizer use efficiency (both N and P); application of 75 g urea (in three split doses) alongwith 75 g superphosphate per tree is the best and most efficient treatment for maximum biomass production of *E grandis* at Minmutti grasslands. This further suports the observation made earlier, based on height, collar circumference and volume of wood produced, that $N_{75}P_{75}$ treatment is the most economical treatment in the locality (Prasad *et al.* 1983 b).

Acknowledgements

Authors express their sincere gratitude to the Eucalyptus Fungus Investigation Unit of the Hindustan Paper Corporation Limited Alwaye for laying out the experiment and extending all possible help during the period of observation. Thanks are also to Shri S.K. Sharma, I.F.S., the then Coordinator, Forest Soil-cum-Vegetation Survey for his able guidence and encouragement during the course of study.

SUMMARY

Biomass production of different components (root, stem, twig and leaf) of one year old *Eucalyptus grandis* due to different doses of urea and superphosphate application at Minmutti, Kerala, was assessed. Application of nitrogen and phosphorus increased biomass production of all tree components. Though, response was greater due to urea application than superphosphate application, combined application of N and P increased biomass production of all plant parts tremendously. Similar to biomass production fertilizer use efficiency was also better due to N and P application alone or in combination. Considering biomass production and fertilizer use efficiency, the treatment receiving 75 g urea along with 75 g superphosphate found to be the most efficient treatment.

अत्यधिक व्याह्रसित मृदाओं में युकेलिप्टस ग्रांडिस का उर्वरीकरण II—जैवपुंज उत्पादन

लेखक के०जी० प्रसाद, जी०एन० गुप्त, एस०बी० सिंह, एस० मोहन, जे० माधवन नायर व ए०डी० देव

सारांश

मिनमट्टी, केरल में यूरिया और सुपरफास्फेट की विभिन्न मात्राएं देकर उगाए जा रहे युकेलिप्टस ग्रांडिस के एक वर्षीय पादपों में विभिन्न अवयवों (जड़, तना, टहनी और पत्तियां) में जैवपुंज उत्पादन का आकलन

किया गया। नाइट्रोजन और फास्फोरस देने से वृक्ष के सभी अवयवों के जैवपुंज उत्पादन में वृद्धि हुई। यद्यपि सुपरफास्फेट देने के मुकाबले में यूरिया देने से वृद्धि का प्रतिचार अधिक पाया गया। नाइट्रोजन और फास्फोरस मिला कर देने से पादपों के सभी भागों में बहुत अधिक वृद्धि हुई। जैवपुंज उत्पादन के समान ही उर्वरक उपभोग किये जाने की सुदक्षता भी नाइट्रोजन या फास्फोरस अलग-अलग या मिला कर देने पर श्रेष्ठतर पाई गई। जैवपुंज उत्पादन और उर्वरक उपभोग की सुदक्षता को देखते हुये सर्वाधिक सुदक्ष उपचार यह पाया गया जिसमें 75 ग्राम सुपर फास्फेट के साथ 75 ग्राम यूरिया प्रति पादप दिया जाता है।

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BIOMASS PRODUCTION AND ENERGY CONVERSION EFFICIENCY BY *EUCALYPTUS* IN ENERGY PLANTATIONS

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Introduction

Eucalyptus hybrid is an exotic species, widely planted in many parts from Punjab in North to Kerala in South, Gujarat in West to West Bengal in East. The minimum rainfall requirement for good growth is around 500 mm annually but with rainfall of 900 mm its growth is excellent. It grows on clay loam though it prefers well drained soil. The appropriate areas for planting this species are Gujrat, Maharashtra, South Rajasthan, Haryana, Karnataka and Tamil Nadu preferably semi-arid areas. Due to its fast growth and high coppicing power, high specific gravity of wood (over 0.75) coupled with good burning quality, it forms an excellent candidate for energy plantations. The results obtained within *Eucalyptus* grown under energy plantation practices forms the subject matter of this paper.

Material and Method

1.5 ha area was planted with *Eucalyptus* with 8357 plants, the density per ha being 5587 plants. A sample plot of 100 m^2 was laid out and height and diameter measurements were carried out at periodic intervals. The plantation is situated in the outskirts of Gandhinagar (Gujarat) (23.07 N Latitude; 72.63 E Longitude; 35 MASL; dry deciduous forests) in a semi-arid tract with the soil of sandy loam. The average annual rainfall is about 700 mm and the average annual temperature is of the order of 30°C; average maximum and minimum temperature being 41°C and 13°C, respectively. The rainfall almost completely occurs during the monsoon months of June to September. The plant to plant and row to row spacing within the plantation was kept constant (1.3 m × 1.3 m) The plantation was fenced with live hedge of *Euphorbia ceducifolia* to protect it from grazing and external interference. Weeding was done only during the first year. Subsequently, the weed growth declined as a result of shade due to close planting. Biomass production in this plantation was estimated at 6 monthly intervals begining 12 months of age. Detailed methodology for estimation of biomass has been published elsewhere (Kaul and Gurumurti, 1982).

Results

Biomass production by trees of different categories in the energy plantation. Of the total number of 5587 trees per hectare, at 12 months of age, 3973 trees were of the category A and 1611 trees were of the category B. The componentwise biomass produced in kilograms by different categories on hectare basis alongwith mean values of various components in the two categories is presented in Table 1. The total biomass of individual components alongwith

their mean values per tree is also presented in the same Table. It is interesting to note that though the number of trees in category B (1614) is less than half that in category A (3976), the contribution of utilizable biomass production per hectare by the former was higher than that of the latter. The total leaf and root biomass of category A was much higher than that of category B. Of the total biomass of 4998 kg produced per hectare at 12 months of age the contribution of category A and B worked out to be nearly 50% each though category B comprised of only 29% of the total trees present in the plantation.

At 18 months of age of the total number of 5587 trees, 80% (4469 trees) comprised of lower GBH category A while 20% (1118 trees) comprised of higher GBH category B. The componentwise biomass produced in kg by different categories on hectare basis, mean values of various components in the two categories and total biomass of individual components and their mean values per tree is presented in Table 2. It was observed that though the category B comprised of 20% of the trees, they contributed to 42% of utilizable biomass, while category A comprising 80% of the population contributed to 58% of utilizable biomass, on hectare basis. It was further observed that the mean leaf biomass of the category B was nearly 2.5 times that of the mean leaf biomass of category A. Accordingly, therefore, mean value of different components of category B was also much higher than that of category A. The leaf efficiency (total biomass/leaf biomass) of the two categories, however, had almost remained very close, of the total biomass of 13599 kg produced per hectare at 18 months of age, contribution of category A was 62%, that of category B was 38%.

At 24 months of age 73% of trees (4063) and 27% of trees comprised of lower (A) and higher (B) GBH category, respectively. The componentwise biomass produced by different categories of trees on hectare basis, mean values of various components in the two categories and the total biomass in the individual component alongwith the mean values are presented in Table 3. It was again observed that the category B comprising 27% of the population contributed to 56% of utilizable biomass whereas category A comprising 73% of population contributed to 44% of utilizable biomass on hectare basis. Ostensibly, the mean value of different components of category B was much higher than that of category A. The mean leaf biomass in category B was over three times that of category A. However, the leaf efficiency values varied only slightly. Of the total biomass 29435 kg produced per hectare at 24 months of growth, the contribution of category A and B was 47% and 53%, respectively.

At 30 months of age, the variation within the population increased further. The data for componentwise biomass production by different categories of trees on hectare basis, mean values of various components in the three categories, total biomass of individual components alongwith the mean values are presented in Table 4 which shows that 73% of the population comprising of category A, 20% comprising of category B and 7% comprising of category C produced 57, 23 and 20% of utilizable biomass. The mean values of leaf biomass showed a direct relationship with mean values of utilizable and total biomass The leaf efficiency, however, again varied only slightly in the three categories of trees Of the total biomass of 38072 kg produced per ha at 30 months of age, the contribution of categories A, B and C was 58, 23 and 19 per cent, respectively, thus showing a very close relationship with utilizable biomass.

Table 1

Componentwise biomass production by trees of different categories of Eucalyptus hybrid plantation at the age of 12 months (kg/ha)

Components	Category		Total	Mean/tree	Details of plantation	Category	
	A	B				A	B
Wood	513	687	1200	0.21	Number of trees	3976	1611
Bark	230	265	495	0.09	Per cent of trees	71	29
Branch	259	288	547	0.10	Per cent contribution of utilizable biomass.	45	55
Utilizable biomass	1002	1240	2242	0.40			
Leaf	830	617	1447	0.26	Per cent contribution of total biomass.	51	49
Root	713	596	1309	0.23	Leaf efficiency	3.1	4.0
Total biomass	2545	2453	4998	0.89			

Table 2

Componentwise biomass production by trees of different categories of Eucalyptus hybrid plantation at the age of 18 months (kg/ha)

Components	Category		Total	Mean/tree	Details of plantation	Category	
	A	B				A	B
Wood	1668	1252	2920	0 52	Number of trees	4469	1118
Bark	787	555	1342	0 24	Per cent of trees	80	20
Branch	970	682	1652	0.30	Per cent contribution of utilizable biomass.	58	42
Utilizable biomass	3425	2489	5914	1.06	Per cent contribution of total biomass.	62	38
Leaf	2074	1355	3429	0.61	Leaf efficiency	4.06	3.82
Root	2930	1326	4256	0.76			
Total	8429	5170	13599	2.43			

Table 3

Componentwise biomass production by trees of different categories of Eucalyptus hybrid plantation at the age of 24 months (kg/ha)

Components	Category		Total	Mean/tree	Details of plantation	Category	
	A	B				A	B
Wood	4783	6081	10864	1.94	Number of trees	4063	1524
Bark	1460	1818	3278	0.59	Per cent of trees	73	27
Branch	1583	1646	3229	0 58	Per cent contribution of utilizable biomass.	44	55
Utilizable biomass	7826	9545	17371	3.11	Per cent contribution of total biomass.	47	53
Leaf	1569	2113	3682	0.66			
Fruit	—	426	426	0.08	Leaf efficiency	8.73	7.45
Root	4297	3659	7956	1.42			
Total	13692	15743	29435	5.27			

Table 4

Componentwise biomass production by tree of different categories of Eucalyptus hybrid plantation at the age of 30 months (kg/ha)

Components	Category			Total	Mean/tree	Details of plantation	Category		
	A	B	C				A	B	C
Wood	6810	3124	2964	12898	2.31	Number of trees	4097	1117	373
Bark	2498	1288	649	4435	0.79	Per cent of trees	73	20	7
Branch	4896	1340	1373	7609	1.36	Per cent contribution of utilizable biomass	57	23	20
Utilizable biomass	14204	5752	4986	24942	4.46	Per cent contribution of total biomass.	58	23	19
Leaf	2725	1130	906	4761	0.85	Leaf efficiency	8.2	7.8	7.7
Fruit	—	—	15	15	0.01				
Root	5336	1944	1074	8354	1.50				
Total	22265	8826	6981	38072	68.2				

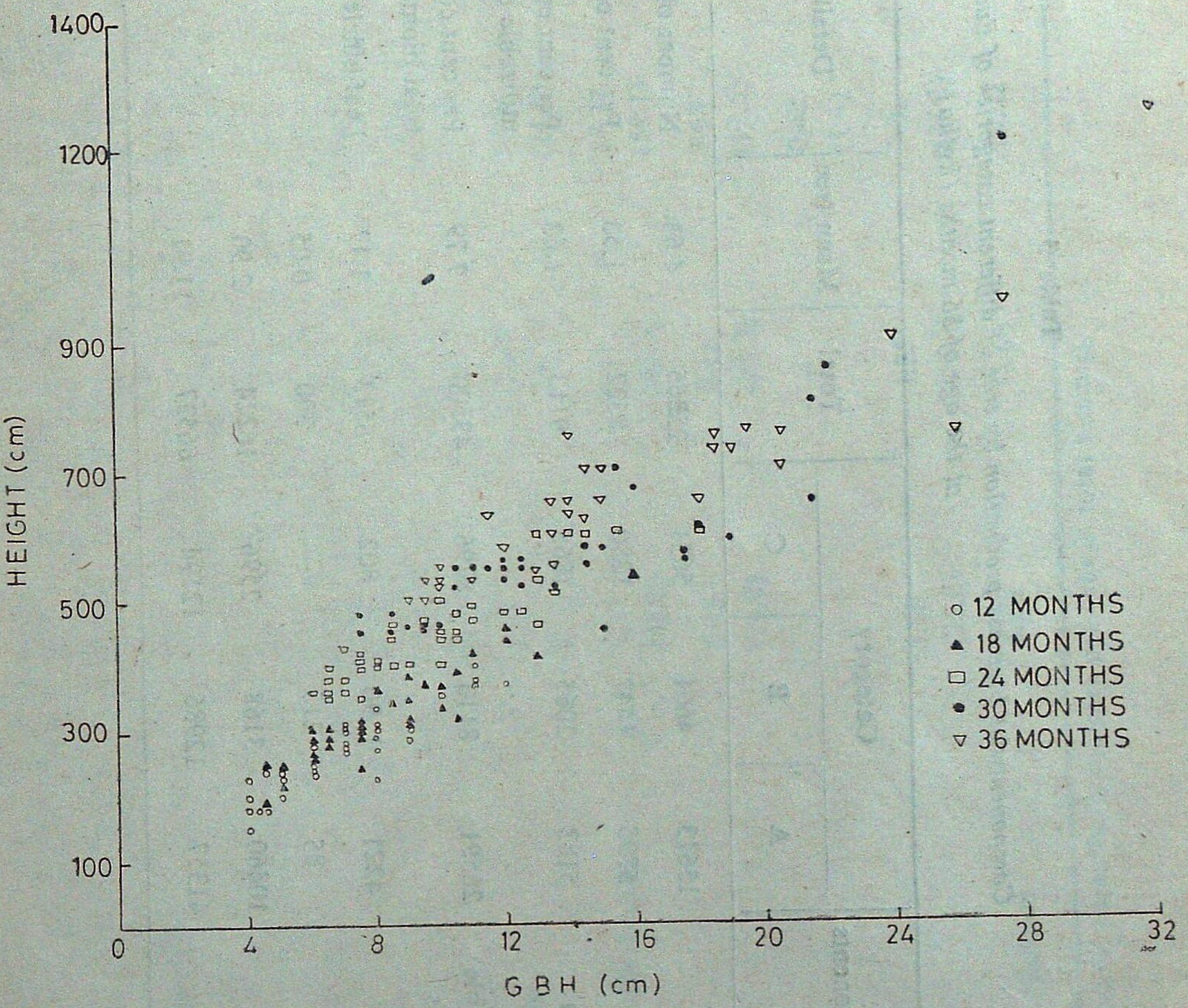
At 36 months of age the percentage variation in the population remained more or less the same, with categories A, B and C comprising 75, 18 and 7 per cent of the total population. The data for componentwise biomass, mean values of various components in the three categories total biomass of individual components alongwith their mean values are presented in Table 5. It shows that category A, contributed to 61% of utilizable biomass, while categories B and C contributed to 19 and 20 per cent of utilizable biomass, respectively. The mean values of leaf biomass of category A and B showed a direct relationship with the mean values of utilizable and total biomass in the same categories. However, there was a disproportionate increase in utilizable and total biomass with respect to leaf biomass in plants comprising of category C which constituted minority (6.7%) of the population. It is noteworthy to mention here that the leaf efficiency of category A and B remained more or less similar but the leaf efficiency of category C nearly doubled. Of the total biomass of 66537 kg produced per hectare the contribution of categories A, B and C was 62, 20 and 18 per cent, respectively, which again showed a parallel relationship with utilizable biomass.

From the foregoing observation it is clear that there exist considerable variations among the population in the plantation. Further, a direct relationship between GBH, height (Fig 1) and biomass production is also evident. These observations also clearly show that higher biomass production by catgories of trees in higher diameter/GBH classes is because of larger number of leaves in these classes and not due to higher leaf efficiency. However, the exception to the above statements should be made with regard to category C of the trees at 36 months of growth as these plants showed much higher biomass production despite proportionately lower leaf biomass. Incidentaly, the leaf efficiency of these plants was also nearly double that of plants in other two categories at 36 months of age indicating the probable genetical variation among the population Alternatively, these plants might have attained maturity leading to more efficient production of dry matter.

Analysis of biomass production at different ages. The data for componentwise and total biomass production in tonnes per hectare alongwith per cent contribution of different components to that of total biomass at 12, 18, 24, 30 and 36 months of age is presented in Table 6. The biomass of different components in creased steadily with age, though the rate of increase of all the components was not similar and the rate of increase of same component at different periods was also not similar. Thus, the wood biomass increased more sharply between 18 and 24 months (May, 1981 to November, 1982) during which period monsoon occurs in the experimental area. Other components also showed a similar trend though not as sharply as that of wood. The per cent distribution of dry matter in different components at different ages showed that per cent contribution of wood biomass to that to total biomass declined at 18 months as compared to that 12 months but increased at 24 months and declined again at 30 months and again increased at 36 months Bark biomass also showed similar rhythmic trend. Per cent contibution of branch bio mass to total biomass showed inverse rhythm when compared to per cent contribution wood and bark biomass at different ages suggesting that photosynthate diversion for dry matter production occurred

alternatively between main bole and branches at different periods of growth. The per cent contribution of utilizable biomass declined slightly from 45 at 12 months to 43 5 at 18 months. At 24 months of age it increased sharply to 59.1 per cent and remaining steady at 65 per cent at 30 and 36 months. The per cent contribution of leaf biomass to that of total biomass declined continuously from 29 per cent at 12 months to 9.8 per cent at 36 months despite the fact that absolute leaf biomass increased showing that non-pnotosynthetic biomass increased at much faster rate. The per cent contribution root biomass to total biomass showed fluctuating trend remaining between 20 and 30 per cent of the total biomass throughout the period of study.

Fig 1



Height Vs GBH of *Eucalyptus* hybird tree in sample plot at different ages.

Table 5

Componentwise biomass production by tree of different categories of Eucalyptus hybrid plantation at the age of 36 months (kg/ha)

Components	Category			Total	Mean/tree	Details of plantation	Category		
	A	B	C				A	B	C
Wood	15613	4601	5651	25865	4.63	Number of trees	4221	993	373
Bark	5795	1447	1280	8522	1.53	Per cent of trees	75	18	7
Branch	5183	2065	1865	9113	1.63	Per cent contribution of utilizable biomass.	61	19	20
Utilizable biomass	26591	8113	8796	43500	7.79	Per cent contribution of total biomass.	62	20	18
Leaf	4221	1 90	802	6513	1.17	Leaf efficiency	9.8	8.7	15.2
Fruit	85	215	—	300	0.05				
Root	10460	3168	2596	16224	2.90				
Total	41357	12986	12194	66537	11.91				

Table 6

Componentwise biomass production of Eucalyptus hybrid at different age (tonnes/ha)

Components	Age (months)				
	12	18	24	30	36
Wood	1.20 (24.0)	2.92 (21.5)	10.86 (36.9)	12.90 (33.9)	25.87 (38.9)
Bark	0.50 (10.0)	1.34 (9.9)	3.28 (11.2)	4.44 (11.7)	8.52 (12.8)
Branch	0.55 (11.0)	1.65 (12.1)	3.23 (11.0)	7.61 (20.0)	9.11 (13.7)
Utilizable biomass	2.25 (45.0)	5.91 (43.5)	17.37 (59.1)	24.95 (65.6)	43.50 (65.6)
Leaf	1.45 (29.0)	3.43 (25.2)	3.68 (12.5)	4.76 (12.5)	6.52 (9.8)
Fruit	—	—	0.42 (1.4)	0.01 (0.0)	0.30 (0.4)
Root	1.30 (26.0)	4.25 (31.3)	7.95 (27.0)	8.35 (21.9)	16.22 (24.4)
Total biomass	5.00	13.60	29.42	38.07	66.54

Figures in parenthesis indicate per cent of total biomass.

Evaluation of growth using various parameters. The data presented in Table 7 represents average total biomass and leaf biomass per tree, which was derived by dividing the total biomass per ha by number of trees per ha. Thus this data represents the average distribution of dry matter per tree in the plantation which was used as basis for calculations of Net Assimilation Rate (NAR); Leaf Weight Ratio (LWR), Relative Growth Rate (RGR), Crop Growth Rate (CGR) at 6 monthly intervals. From the data presented in this Table, it is clear that the total biomass, leaf biomass, as well as the leaf efficiency in this species increased linearly with age. However, the data presented for NAR, LWR, RGR and CGR in Table 7 showed a different trend. Thus NAR slightly increased during 12 to 18 months of growth as compared to that during 0 to 12 months. It showed two peaks one at 18-24 months of growth and another at 30-36 months of growth. Incidentally, it is during these period the wood biomass as well as the total biomass production registered sharp increase thus, suggesting that the moisture availability influences the growth as during these periods most of the rainfall occurred in the experimental area. The decline in values of LWR and RGR with age is due to the fact that the rate of dry matter accumulation in non-photosynthetic biomass was at higher level as compared to that in the photosynthetic biomass. The crop growth rate showed a fairly close correlation with NAR ($\gamma = 0.76$). RGR was found to be highly correlated with LWR as the value of coefficient of correlation between these factors worked out to 0.88.

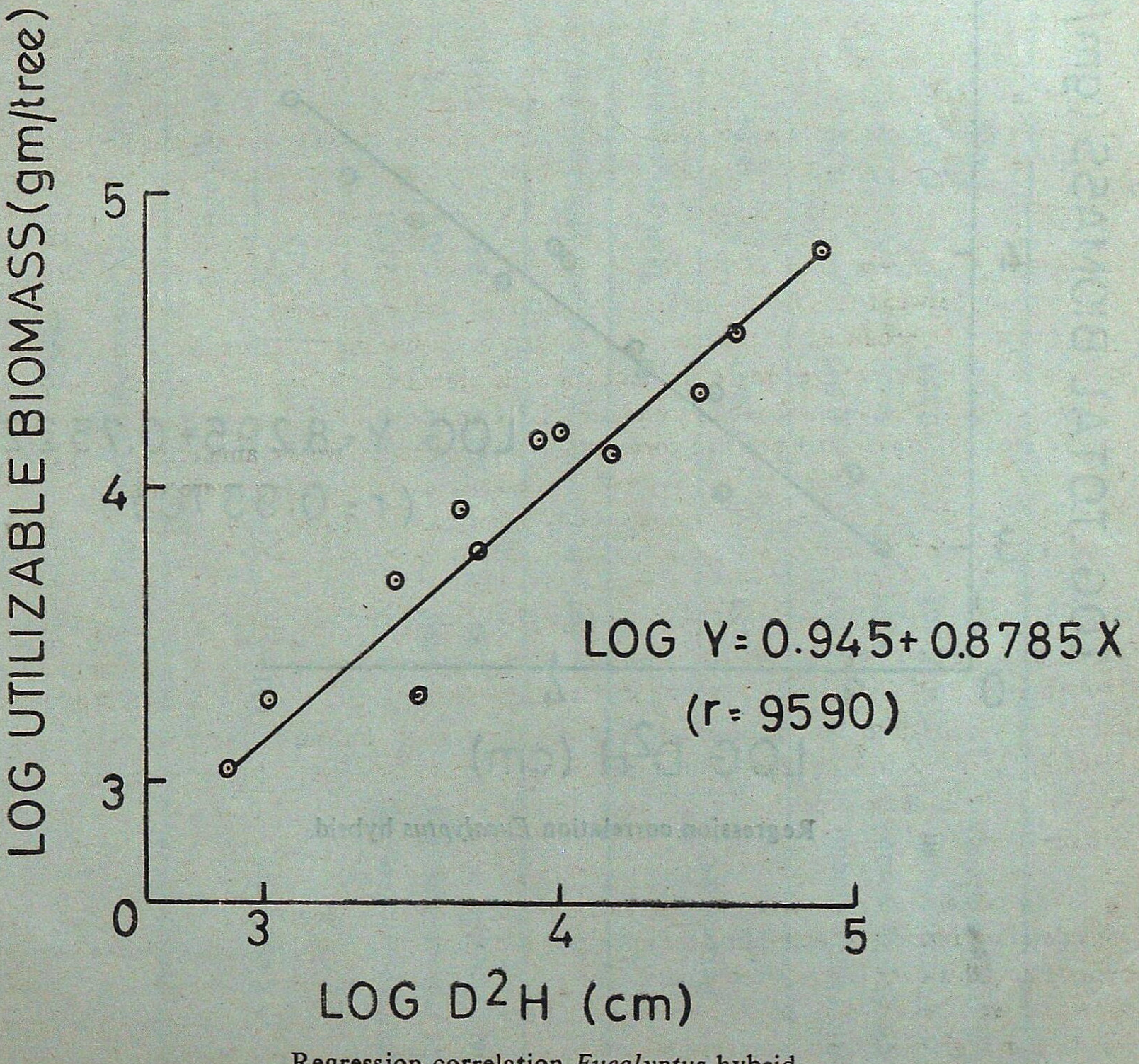
Relationship between D^2H and total dry matter and utilizable dry matter per tree. The relationship between square of diameter multiplied by the height (D^2H) and total/utilizable dry matter produced by the tree, was worked out using their log values and the results alongwith the respective regression equation is presented in Fig 2. It was found that the value for both D^2H and utilizable dry matter, L^2H and total dry matter worked out to 0.96 suggesting a linear and positive correlation between these two parameters. It is also clear from the Fig. 2 that the observed values of utilizable/total dry matter were fairly close to regressed values. The results thus suggest that D^2H may be used as parameter for determining utilizable and total dry matter production per tree.

Standing energy content and solar energy conversion efficiency. The data on energy contents of various components on hectare basis and energy conversion efficiency at different ages of growth as well as the periodic energy conversion efficiency is presented in Table 8. The bulk of the energy is fixed in wood biomass, the componentwise and total energy levels showing essentially similar trend as that of biomass content. The energy (PAR) conversion efficiency was found to increase rapidly with age. Which is a reflection of increase in photosythetic surface leaf (Fig. 3).

In view of the earlier observations that there exists a periodicity in growth, it was considered of interest to determine the energy conversion efficiency between two consecutive periods and this data is also presented in Table 8. The seasonal energy conversion efficiency showed two peaks one at 18-24 months of growth and another at 30-36 months of growth resulting in high NAR and biomass production during these periods. The most interesting

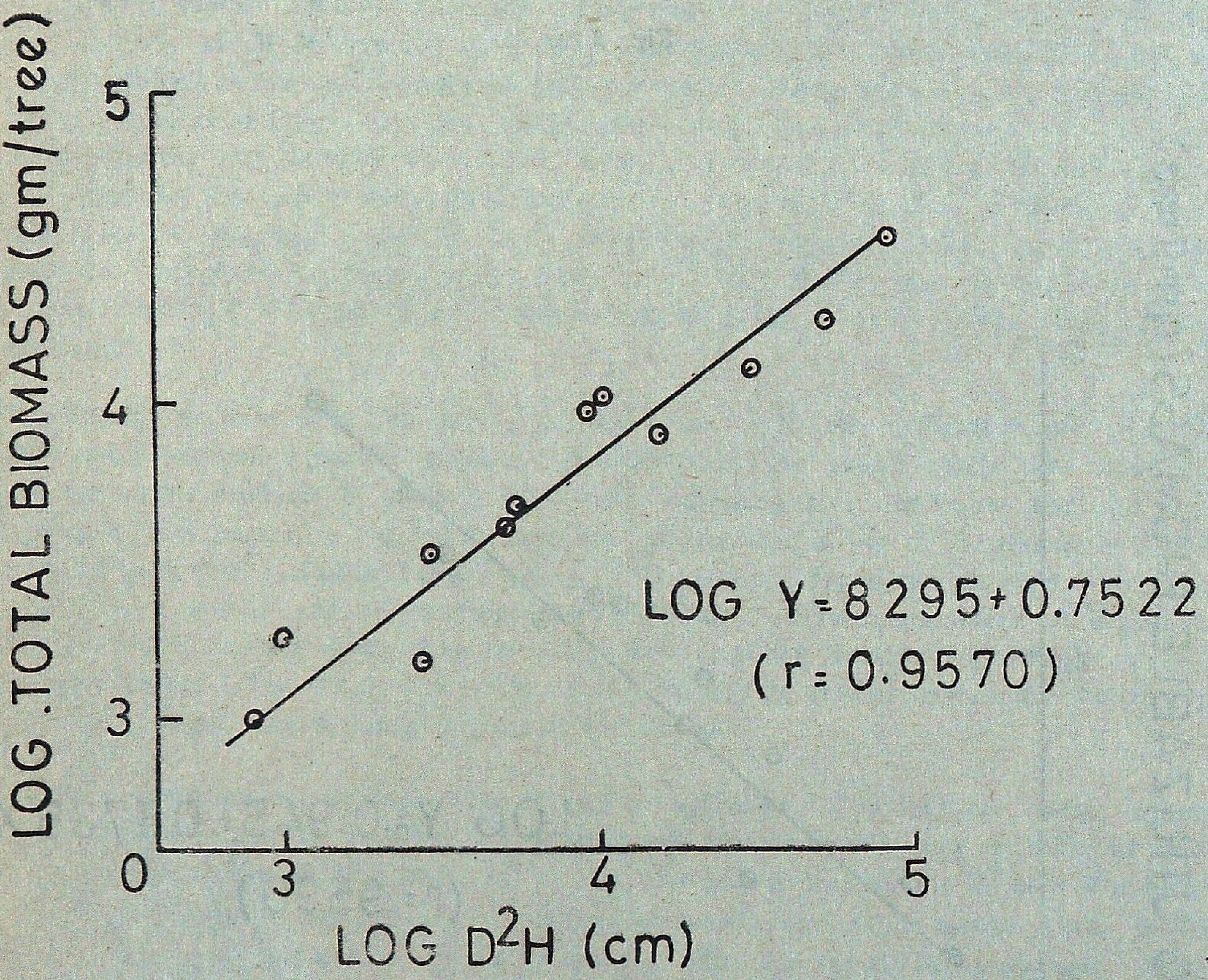
aspect of this data is that periodic energy conversion efficiency is very high, the highest value being 3.16 per cent at 30-36 months of growth, which suggests that forests plants have great capacity for converting the solar energy into dry matter but this capacity is greatly influenced by various environmental pa ameters. In the present study the high levels periodic energy conversion efficiency at 18-24 and 30-36 months of growth is probably due to moisture availability as rainfall occurs during these periods in the experimental area. Even during periods when rainfall was practically negligible (at 12-18 and 24-30 months of growth), the figures for periodic energy conversion efficiency is fairly high as compared to many forest plantations which may be attributed to large number of stems per hectare.

Fig. 2 (a)



Regression correlation *Eucalyptus* hybrid

Fig. 2 (b)



Regression correlation *Eucalyptus* hybrid.

Table 7

Growth parameters of Eucalyptus hybrid at different ages.

Parametres	Age (months)					
	0	12	18	24	30	36
Total biomass/tree (kg)	0.005	0.890	2.430	5.270	6 820	11.910
Leaf biomass/tree (kg)	0.002	0 260	0 610	0.660	0.850	1.170
Leaf efficiency	2.50	3.42	3.98	7.98	8.02	10.18

Analysis of growth in Eucalyptus hybrid plantations

Parameters	Time period (months)				
	0-12	12-18	18-24	24-30	30-36
NAR (kg/kg month)	0.563	0 590	0.745	0 342	0.840
LWR (kg/kg/month)	0.293	0.262	0.165	0.125	0 108
RGR (kg/kg/month)	0.165	0.155	0.123	0.043	0.091
CGR (tonnes/month)	0.420	1.430	2 640	1 440	4.7.0

Table 8

Total standing energy content of Eucalyptus hybrid at different ages ($\times 10^6$ kcal)

Components	Age (months)				
	12	18	24	30	36
Wood	4.39	11.6	60.04	67.34	123.44
Bark	1.15	4.7	13.35	15.49	34.18
Branch	2.30	6 66	12.00	33.05	42.20
Energy in utilizable biomass	8.14	22.96	85.39	115.88	199.72
Fruit	—	—	1.57	0.07	1.65
Leaf	5.59	16.43	18.09	21.75	28.79
Root	4.86	18.43	25.27	39.52	76.94
Energy in total biomass	18.59	57.7	130.32	177.22	307.10

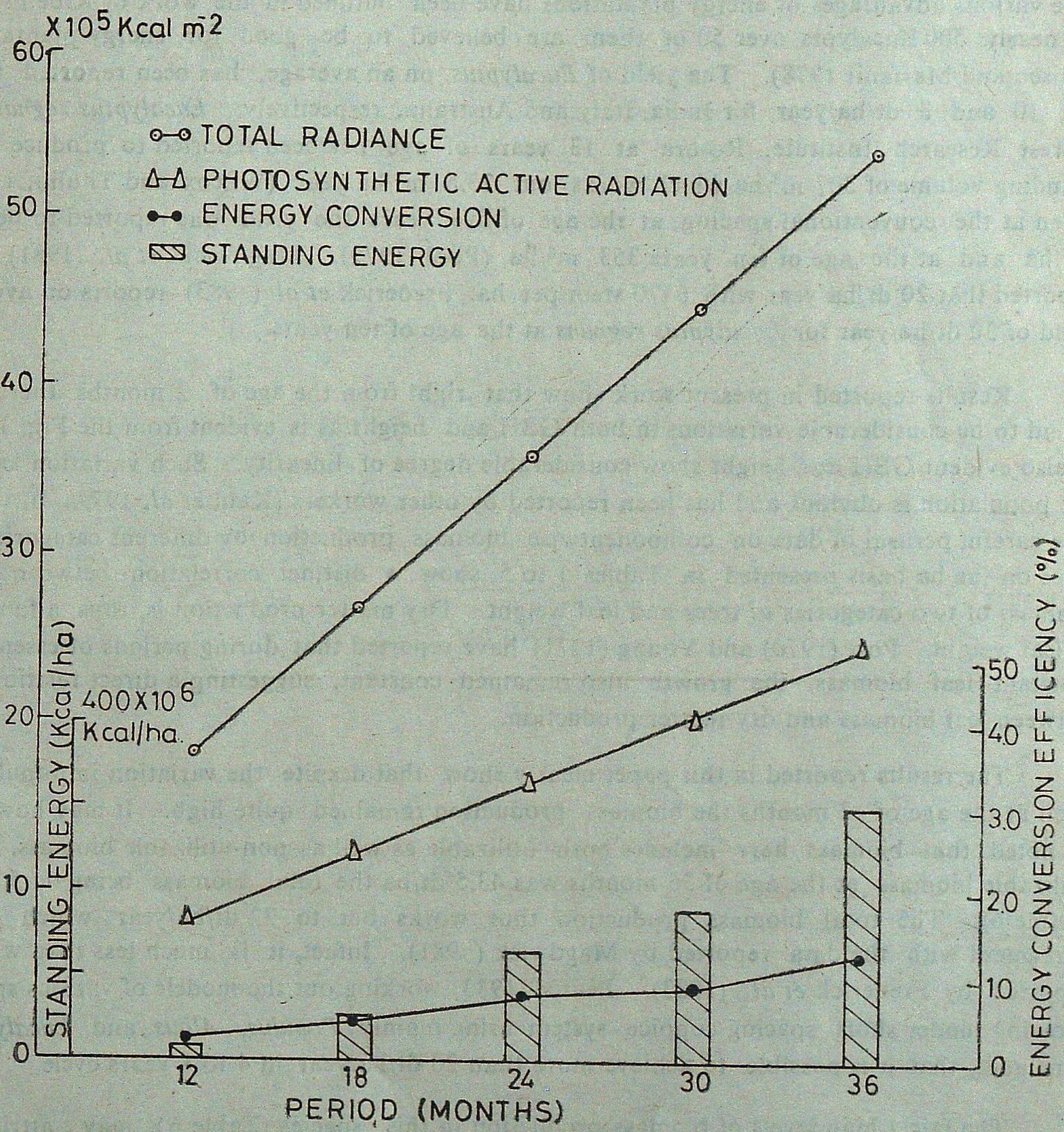
Solar energy conversion efficiency by Eucolyptus hybrid (%)

Age (months)				
12	18	24	30	36
0.24	0.48	0.80	0 88	1.26

Seasonal energy conversion efficiency by Eucalyptus hybrid (%)

Time period (months)			
12-18	18-24	24-30	30-36
0.97	1.77	1.17	3.16

Fig 3



Standing energy and solar energy conversion efficiency of *Eucalyptus* hybrid.

Discussion

The need for high demand of wood has necessiated the short rotation forestry also called the energy plantations. Yields in short rotation forestry can be increased to 12 to 25 dt/ha/year in 4 to 10 year cycle (Gibson, 1978). Such energy plantation approach is being pursued by several workers (Saucier *et al.* 1972; Young 1972; Schmidt and De Bell, 1973). The various advantages of energy plantations have been outlined in the work of Ribe (1974. Of nearly 500 Eucalypts over 50 of them are believed to be good for energy plantations (Eliseo and Marianii 1978). The yield of *Eucalyptus*, on an average, has been reported to be 16, 10 and 8 dt/ha/year for India, Italy and Australia, respectively. *Eucalyptus regnans* at Forest Research Institute, Rotora at 13 years of age has been reported to produce total standing volume of 307 m^3/ha which works out 23.6 m^3/ha/year (Wilcox and Thulin, 1979). Even at the conventional spacing, at the age of five years the yield was reported to be 145 m^3/ha and at the age of ten years 353 m^3/ha (Pool 1979). Magdwick *et al.* (1981) have reported that 20 dt/ha/year with 6470 stem per ha. Frederick *et al* (983) reports on average yield of 30 dt/ha/year for *Eucalyptus regnans* at the age of ten years.

Results reported in present work show that right from the age of 2 months there was found to be considerable variations in both GBH and height as is evident from the Fig. 1. It is also evident GBH and height show considerable degree of linearity. Such variation among the population is obvious and has been reported by other workers (Kaul *et al.* 1979a, b, 1982). The careful perusal of data on componentwise biomass production by different categories of trees on the ha basis presented in Tables 1 to 5, show a distinct correlation between total biomass of two categories of trees and leaf weight. Dry matter production is, thus, a function of leaf weight. Post (1970) and Young (1971) have reported that during periods of essentially constant leaf biomass, the growth also remained constant, suggesting a direct relationship between leaf biomass and dry matter production.

The results reported in this paper clearly show that despite the variation in population even at the age of 12 months the biomass production remained quite high. It may however, be noted that biomass here includes both utilizable as well as non-utilizable biomass. The utilizable biomass at the age of 36 months was 43.5 dt/ha the total biomass being 66.5 dt/ha (Table 6). The total biomass production thus works out to 22 dt/ha/year which is in agreement with the data reported by Magdwick (981). Infact, it is much less than what is reported by Frederick *et al.* (1983). Pearce (1983) working out the models of various species growing under short spacing coppice system using mainly *Populus*, *Albus* and *Eucalyptus* concludes that it is possible to achieve more than 20 dt/ha/year in 4 to 8 years cycle.

The fairly high levels of biomass production in this species (Table 6) may attributed to short spacing coupled with fast growing nature of plants However, the exact relationship between spacing and yield has not been reported for many of the forest plants. The traditional spacing 2 m × 2 m or 2 m × 3 m may be beneficial for long rotation plantations which have timber value viz, teak, sal, etc. When the question of increasing dry matter production per unit area is concerned, short spacing with shorter rotation may be beneficial (White and

Plaskett, 1981). Our work, thus, supports this view. Short spacing with the dense foliage in a given area may also have other implication like increase in energy conversion efficiency through enhanced CO_2 profile within the microclimate of such system and it is possible to stimulate the growth of tree plants by enhancing the CO_2 concentration in the environment (Stanley, 1971). Sparling and Alt (1969) studying the CO_2 level in coniferous and deciduous stands report that in coniferous stands (which are fully leaved) high CO_2 levels occur just before early morning, being 526 ppm, which rapidly started being assimilated from 8 A.M. onwards reaching equilibrium level by mid-day. In the present *Eucalyptus* energy plantation also the possibility that CO_2 levels might increase due to dense canopy particularly in early morning, is relevant which has implication in improving the CO_2 fixation efficiency of RuP_2 carboxylase and reducing the process of photorespiration, the latter being wasteful (Chollet and Ogren, 1975). All these aspects are reflected as higher assimilation rate as well as high solar energy conversion efficiency by the *Eucalyptus* under energy plantation practices (Table 7 and 8, Fig. 3).

The relationship between the square of diameter multiplied by height (D^2H) for both total and utilizable dry matter production presented in the Fig. 2 suggests that it is possible to predict the biomass using these two variables in case of *Eucalyptus*. The solar energy conversion efficiency increased with increase in age (Table 8, Fig 3), which is obvious. However, the seasonal energy conversion efficiency showed fluctuating trends with higher values at 18-24 and 30-36 months periods, being 1.77 and 3.16%, respectively. Such high seasonal energy conversion efficiency, hitherto unreported in literature may be due to combination of factors like large number of stems, large leaf area, increase in CO_2 profile coupled with enormous increase in the stomatal aperture during early morning in *Eucalyptus* (unpublished data from this Branch). Needless to state that in such systems the nutrient dynamics has also been worked out which however will form the subject matter of another paper. It my be concluded that the possibilities of improving biomass production per unit of time and area through energy plantations practices exist even with the availability of existing genetic material. The fact that high yields can be obtained even under semi-arid non-irrigated conditions open up new horizons not only the field of biomass production but also in the field of community behaviour by even aged plantation in terms of CO_2 profile water, balance and energy conversion efficiency.

SUMMARY

Studies on growth, assimilation rate, biomass production, solar energy conversion efficiency and seasonal energy conversion efficiency by Eucalypts under energy plantation practices (short spacing, 1.3 m × 1.3 m) have been carried out at six monthly intervals for a period of 36 months under semi-arid non-irrigated conditions in Gujarat. The results show that there exists considerable variation among the population of the trees which increase with increasing age. The total biomass ranged from 5 dt/ha at 12 months to 66.5 dt/ha at 36 months,

the utilizable biomass (wood, bark, branch) ranging from 2.25 dt/ha to 43.5 dt/ha for the same periods. There existed a direct correlation between, the leaf biomass and total biomass by different categories of trees. The results on various growth parameters, viz, net assimilation rate, relative growth rate and crop growth rate is also presented. The relationship between D^2H and total as well as utilizable dry matter production by trees has been worked out and presented. The solar energy conversion efficiency was found to be maximal at 36 months of the age being 1.26. The seasonal energy conversion efficiency showed two peaks, one 18-24 and another 30-36 months, the values being 1.77 and 3.16 per cent of *PAR* coinciding with the periods of moisture availability. The high biomass production by trees under energy plantation practices as related to the CO_2 profile and energy conversion efficiency is briefly discussed

ऊर्जा रोपवनों में युकेलिप्टस का जैवपुंज उत्पादन तथा ऊर्जा परिवर्तन की सुदक्षता

लेखक के० गुरूमूर्ति, एम०एम० किमोथी, डी०पी० रतूड़ी व जे०एस० रावत

सारांश

गुजरात में अर्द्ध-शुष्क असिंचित दशाओं में 36 मास की अवधि तक 6-6 महीने के अन्तर पर उर्जा उत्पादन की प्रक्रियाओं (फासला थोड़ा देकर 1.3 × 1 3 मी०) युकेलिप्टस की वृद्धि, सात्मीकरण दर, जैवपुंज उत्पादन, सौर ऊर्जा परिवर्तन सुदक्षता और मौसमी ऊर्जा परिवर्तन सुदक्षता का अध्ययन किया गया। परिणामों से पता चलता है कि वृक्षों की संख्या में काफी विभिन्नता वर्तमान रहती है जो उम्र बढ़ने के साथ बढ़ती चली जाती है। जैवपुंज का कुल उत्पादन 12 महीने की उम्र में 5 डीटी/हेक्टे० से 36 महीने की उम्र होने पर बढ़ कर 66.5 डीटी/हेक्टे० हो गया, उपयोज्य जैवपुंज (लकड़ी, छाल, शाखाएं) उसी अवधि के दौरान 2.75 डीटी/हेक्टे० से 43.5 डीटी/हेक्टे० हो गया। वृक्षों की विभिन्न श्रेणियों में पत्तियों के जैवपुंज और कुल जैवपुंज में सीधा सह सम्बन्ध पाया गया है। वृद्धि के विभिन्न परिमाप अर्थात् शुद्ध सात्मीकरण दर, आपेक्षिक वृद्धि दर और सस्य वृद्धि की दर भी दिये गये हैं।

व्यास^2 × ऊंचाई और कुल तथा उपयोज्य शुष्क पदार्थ उत्पादन का वृक्षवार सह सम्बन्ध भी स्थापित तथा प्रस्तुत किया गया है। सौर ऊर्जा परिवर्तन सुदक्षता 36 महीने उम्र रहने पर अधिकतम यानी 1.26 रही। मौसमी ऊर्जा परिवर्तन सुदक्षता के दो शिखर रहे, पहला 18-24 वें तथा दूसरा 30-36 वें महीने की उम्र पर जिनके मान आवधिक वार्षिक वर्षा (PAR) के 1.77 व 3.16% रहे जो आद्रता मिलने की अवधि में पड़ते हैं। विभिन्न रोपण प्रक्रियाओं में वृक्षवार अधिक जैवपुँज उत्पादन को कार्बन डायोक्साइड पार्श्व और ऊर्जा परिवर्तन सुदक्षता से सम्बन्धित करते हुए संक्षेप से इस लेख में विमर्शित किया गया है।

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ECONOMICS OF *EUCALYPTUS* PLANTATIONS UNDER AGRO-FORESTRY

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Increasing attention is being paid to large scale afforestation programmes, social forestry programmes, agro-forestry programmes etc. Under these programmes, emphasis is being given to raising multipurpose fast growing tree species. *Eucalyptus* is one of the exotic genera which has shown its adaptablity to a wide range of environments and have been extensively planted almost throughout the country.

Eucalyptus offers the widest assortment of uses. It has been liked very much as a plantation species, as it yields high volume production on short rotations of 6 to 8 years. It can produce firewood, small timber and poles, and is used in house construction in the form of beams, and for making crates for storing food grains, etc. It provides an important source of paper and rayon grade pulp. The leaves of *Eucalyptus* are used for distilling essential oils and bark for producing oxalic acid.

Suitability of *Eucalyptus* to Agro forestry

Increasing the productivity of our limited forest land is the foremost consideration at present. In this context *Eucalyptus* has proved best in our plantation programmes.

Eucalyptus hybrid (*E. tereticornis*) or Mysore gum is capable of adapting itself to a wide variety of habitats It is raised in plantations from the sea-level to 1000 m in tropical to sub-tropical climates with a rainfall of 400 to 4000 mm It grows on a variety of soils including coastal and black cotton soil. However, well drained deep and fertile soils are best. The tree is a light demander and is resistant to fire. It does not cast much shade *Eucalyptus* tree shed their leaves, twigs, branches and bark, leading to nutrient recycling in the soil. It has the ability to grow on exposed sites without shelter. It can withstand long, severe dry seasons.

Eucalyptus tereticornis has shown promise in *usar* soils in Uttar Pradesh. Many species of *Eucalyptus* develop underground swellings termed as lignotubers which make *Eucalyptus* to survive under adverse conditions.

The root system of *Eucalyptus* is usually of a spreading type, the root penetrates 1 to 3 m in the ground and superficial spreading to a distance of about 1 to 3 m.

Eucalyptus is a good coppicer and two coppice rotations have been successfully tried in India so far.

Due to these above characters and fast rate of growth *Eucalyptus* hybrid has been liked very much by farmers. Planting of *Eucalyptus* has been done by the farmers in Northern India on field bunds, in strips along field boundaries, in rows along water channels, on farm apporach roads and in compact blocks in fields and village common lands, with variable spacings.

A shift in the cropping pattern especially from agriculture to Farm-forestry has been experienced in the states of Haryana/Punjab and Uttar Pradesh. The most important consideration affecting this change to the cropping pattern is the economic consideration.

Economics of *Eucalyptus* under Agro-forestry

Agro-forestry is recognised to be on economically viable propositions. Case studies conducted in Rajasthan (Gupta and Mohan, 1979), Terai area of Uttar Pradesh (Nesargi, 1978), and Gujarat (Gurumurti, 1981a) have clearly demonstrated the economic potential of silvi-pastrol, agri-silvicultural and farm-forestry activities.

In a recent case study in Haryana it has been estimated that economic gains accrueing from social forestry to the landless, sub-marginal land holders (2 to 5 ha) and farmers with large holdings (over 5 ha) are computed to be about Rs. 500, 2,270, 6,600 and 17,200 per annum respectively.

Experiments in U.P. (Lohani, 1980) have shown that spacing of 2.5 m × 2.5 m produces maximum volume. The next best spacing has been found to be 3 m × 1.5 m. However, for 8 years rotation, to have maximum volume per tree (Lohani, 1980) and lesser cost of production such as cost of seedlings, digging of pits, providing fertilizers, irrigation, etc. and weeding, the wider spacing of 4 m × 2 m and 6 m × 1 m have also been considered. It may have added advantages like getting Agricrops for longer period and appears to be an efficient spacement from the point of view of production of larger diameter stems.

In farms where the soil is well worked deep and rich, *Eucalyptus* can give very high returns on investments. Economics of these plantations raised at some suitable spacing and harvested at appropriate rotations have been calculated to illustrate the methodology. The economic feasibility of *Eucalyptus* hybrid both with or without agriculture under varying spacing viz., 2.5 m × 2.5 m, 3.0 m × 1.5 m, 4.0 m × 2.0 m and 6.0 m × 1.0 m, as practised by farmers in U.P., Punjab and Haryana has been worked out.

(a) *Plantations raised in fields without agriculture crops. Eucalyptus* hybrid plantations are normally worked at a rotation of 8 years in forests of the orthern region. On a good type of forest soil with the spacement of 2.5 m × 2.5 m and 3 m × 1.5 m (total number of plants planted per ha 1600 and 2222) an yield of 106.1 m^3 (UB) and 78.92 m^3 (UB) is obtained at 8 years age respectively (Lohani, 1980). This yield is reduced by 6.1 m^3 and 3.92 m^3 as a safety factor so that the benefits may not be over estimated. Thus the yields, considered for calculations will be 100 m^3 and 75 m^3 after 8 years for the spacement 2.5 m × 2.5 m and 3.0 m × 1.5 m respectively.

Plantation works and costs. Various operations viz., site clearance, fencing, soil working etc. carried out in raising plantations on forest lands have not been taken into account as these are not carried out on farm lands. Only a few items viz. application of pesticides, interculture operations etc. have been included. Cost items pertaining to establishment of plantations without Agriculture are given in Table 1. Expenditure made on the maintenance of the first coppice crop is given in Table 1 (a). It is assumed that this expenditure will be the same in case of second and third coppice crop An abstract of cost in respect of both spacing viz. 2.5 m × 2.5 m, 3 m × 1 5 m is given in Table 1 (b).

Table 1

Cost of formation of Eucalyptus hybrid plantation (only Main Crop)

(Espacement—2.5 m×2.5 m – Planted 1600 Plants/ha)

Labour Rate Rs. 10/- Manday

Year	Head of works and operations	Total cost per ha (Rs.)	Remarks
1	2	3	4
I	1. *Pre-planting works* :		
	(a) Boundary demarcation and alignment of proposed area.	40	
	(b) Cattle proof Fencing : @ 4 Strands barbed wire fence	900*	*This cost is based on a 10 hectare Sq. plot. required 420 poles for 3 m apart and approximately 5100 m barbed wire. But not included in the cost stream assuming that the farm area is already fenced otherwise a watcher is posted.
	(c) Digging of 1600 pits sized 30 cms × 30 cms @ Rs. 0.30 per pit.	480	
	(d) Aldex 10% per BHC 30 gms per pit @ Rs. 2.50 per kg for 1600 plants.	120	
	(e) FYM, 3 to 4 kgs per pit @ Rs. 120 per Tractor Trolly-Charges upto site – 2 Trolly required.	240	
	(f) Filling of pits and mixing of manure BHC/Aldrex, @ Rs. 10 per 100 pits.	160	

(*Contd...*)

1	2	3	4
	2. *Planting and Post-planting works :*		
	(a) Cost of 1600 Polythene bags seedlings-40 Paisa per seedling.	640	
	(b) Loading, transport and unloading of Plants at nursery and site @ Rs. 20/- per 100 plants upto 15 kms.	320	
	(c) Planting of 1600 plants @ Rs. 10 per 100 plants.	160	
	3. *Weeding* – Two in number (Assuming, one man will weed 100 plants in a day, for second weeding this cost will be 60% of first weeding).	260	
	4. *Irrigation*—two during summer.	160	
	5. Insecticides and applying there of.	90	
	6. Sowing of seeds of babul/syzygium jambolana along the boundary.	60	
	7. Supervision of Plantation by a watcher @ Rs 250 per month per ha (for 10 ha) otherwise a family member part time.	300	
	8 Executing expenses or services of a person (skilled in plantation works) and unforseen charges.	250	
	Total	3280	
II.	1. *Replacement of Casualities :*		
	25% of orginal number of plants replaced and the following costs included (a) cost of Plants, (b) Planting (c) Transporting. (d) Fertilizers (e) BHC/Aldrex and (f) Irrigation etc.	334	

(Contd...)

1	2	3	4
	2. *Weeding*—One @ Rs. 10/- per 100 plants.	160	
	3. *Fertilizers* in two Doses : (a) 200 kgs Urea and (b) 100 kgs Superphospate.	660	
	4. Irrigations two during the year.	160	
	5. Plantation Watcher and other General Supervision.	300	
	6. Misc unforeseen charges.	150	
	Total	1,764	
III. & IV.	1. Plantation Watcher including General Supervision.	300	
	2 Irrigation two times during each year	160	
	3. Misc unforeseen charges	300	
	Total	760	
V.	1 Plantation Watcher and Supervision.	300	
	2. Irrigation one at the time at summer.	80	
VI.	1. Plantation watcher and supervision	300	
	2. Collection, Drying and Storage of 60 kg seeds from selected trees.	150	
VII.	Same as during VI year.	450	
VIII.	1. Plantation Watcher and General upervision.	300	
	2. Collection, drying and storage of 80 kgs seed from selected trees.	200	

Note : For a medium size farm, say 5-10 hectare, managerial works will be done by the owner himself. Therefore no charges, being kept seperately for this purpose Plantation will be harvested at the end of 8th year (8 year rotation basis).

Table 1 (a)

Hectare Maintenance Cost (in Rupees) of 1 coppice of Eucalyptus hybrid Plantation at the spacing of 2.5 m × 2.5 m or 1600 Plants per hectare

(Cost for other espacements adjusted accordingly)

Sl. No.	Head of Inputs, works etc.	Age of coppice crops in years.							
		I	II	III	IV	V	VI	VII	VIII
1	2	3	4	5	6	7	8	9	10
1.	Water charges for Irrigation @ Rs. 63 per Irrigation.	60	120	120	120	120	60	—	—
2.	Labour for Irrigation work.	20	40	40	40	40	20	—	—
3.	*Trace Elements*:								
	(a) Zinc sulphate, 30 gms/tree approximately. 50 kgs required @ Rs. 1 per kg.	50	50	—	—	—	—	—	—
	(b) Ferrous sulphate, as above Zn SO_4. @ Rs. 1.50 kg.	75	75	—	—	—	—	—	—
	(c) Labour for applying above elements.	40	40	—	—	—	—	—	—
4.	Singling of coppice shoots.	60	30	—	—	—	—	—	—
5.	Urea–125 gms/tree 2 Qtls Urea required @ Rs. 200 per quintal.	—	440	400	—	—	—	—	—
6.	Labour for applying Urea.	—	40	40	—	—	—	—	—
7.	Weeding or soil work around trees, assuming 1 man will weed 100 trees.	160	160	160	—	—	—	—	—
8.	Collection, drying and storge of *Eucalyptus* seed, collected from selected trees.	—	—	—	—	—	125	125	175
9.	Plantation Watcher-cum-Caretaker—part time lab of a family member or by the owner.	300	300	300	300	300	300	300	300
10.	Miscellaneous and other unforeseen expenses.	100	100	100	100	100	100	100	100
	Total	865	1355	1160	560	560	605	525	575

Table 1 (b)

Per hectare Expenditure for 2 crops (incl one coppice crops) of Eucalyptus plantation made at different spacing (unit in Rupees)

Plantation age (years)	Crops	Espacement in metres	
		2.5 × 2.5 (1600 Plants)	3 × 1.5 (2222 Plant)
1	2	3	4
1.	Main	3280	4097
2.	-do-	1764	1960
3.	-do-	760	760
4.	-do-	760	760
5.	-do-	380	380
6.	-do-	450	480
7.	-do-	450	450
8.	-do-	500	530
9.	I-Coppice	865	967
10.	-do-	1355	1682
11.	-do-	1160	1335
12.	-do-	560	560
13.	-do-	560	560
14.	-do-	605	630
15.	-do-	525	550
16.	-do-	575	600

Benefits from plantations. The plantations raised at the spacings of 2 5 m × 2.5 m and at 3.0 m × 1.5 m will provide wood in different sizes at 8 years age depending on growth and form of trees. It can yield logs, poles and firewood under various diameter class distribution presented below (Lohani, 1980).

Diameter class distribution of trees in the spacement of 1.5 m × 2.5 m and 3 0 m × 1.5 m

Spacing (m)	Age (yrs)	Percentage of trees in diameter class						Average diam. in 8 years. (cms)
		0-4	4-8	8-12	12-16	16-20	20-24	
2.5 × 2.5	7	2.0	13.0	38.8	33.6	10.2	1 6	14.10
3.0 × 1.5	7	3.8	28 8	43.8	21.3	2.9	—	11.70

A plantation raised at 2.5 m × 2.5 m and 3.0 m × 1.5 m shall give a return of Rs. 40,000 and Rs. 30,000 per ha respectively at 8 years age, the average yield being taken as 100 m^3 and 75 m^3 (safety factor of 6.1 m^3 and 3 92 m^3 respectively) per ha (Lohani, 1980). These yields are evaluated at the rate of Rs. 400 per m^3 (UB), Besides timber and firewood, returns will also be obtained from the sale of *Eucalyptus* seeds and grasses. Details of these returns are given in Table 1 (c).

Cost/benefit Analysis. Yearwise costs and returns for main crop including three coppice rotations without intercropping were pooled up and cost/benefit analysis has been worked out for 2.5 m × 2 5 m and 3.0 m × 1.5 m spacings and presented in Table 1 (d) and 1 (e). The results in the form of net present value (NPV), Benefit/Cost ratio (B : C) and Internal Rate of Returns (I R) worked out at the end of 4 rotations (one main crop and 3 coppice crop) are summarised below.

Spacing	NPV (Rs/ha) @			B : C @			IRR	Remarks
	12%	15%	18%	12%	15%	18%	Approx.	
2.5 × 2.5 m	21422	14986	10557	3.43	2.98	2.56	40%	Without agriculture.
3.0 × 1.5 m	14687	9788	6526	2.45	2.12	1.84	32%	-do-

It may be noted from the above table that planting of *Eucalyptus* at 2.5 m × 2.5 m spacing gave higher returns as compared to 3.0 m × 1.5 m spacing, in all criteria viz., NPV, B/C ratio and IRR.

Table 1 (c)

Benefit received from one hectare of Eucalyptus pure plantation planted at different spacings.

Age in Yrs.		Head of outputs	At 2.5 m × 2.5 m				At 3.0 m × 1.5 m			
Plantation	crop		Main	I	II	III	Main	I	II	III
1	2	3	4	5	6	7	8	9	10	11
2, 3, 4 & 5	2, 3, 4 & 5	Sale of standing grasses grown and maintained in the plantation area @ Rs [illegible]00 per year.	2000	2000	2000	2000	2000	2000	2000	2000
6 & 7	6 & 7	(a) Sale of standing grasses grown in the area @ Rs 300 per year.	600	600	600	600	600	600	600	600
		(b) Sale of *Eucalyptus* seed @ Rs. 20 per kg collected from selected trees.	2400 (60 kg/yr)	2000 (50 kg/yr)	2000 (50 kg)	2000 (50 kg)	2800 (70 kg/yr)	2400 (60 kg)	2400 (60 kg)	2400 (60 kg)
8	8	(a) Net receipt from sale of standing grasses in the plantation area	300	300	300	300	300	300	300	300
		(b) Sale of *Eucalyptus* seed @ Rs 20/kg.	1600 (80 kg/yr)	1400 (70 kg)	1400 (70 kg)	1400 (70 kg)	1800 (90 kg/yr)	1600 (80 kg)	1600 (80 kg)	1600 (80 kg)
		(c) Sale of estimated (UB) standing volume of *Eucalyptus* trees of original crop. Sale price Rs. 400/- m^3	40000 (100 m^3)	34000 (85 m^3)	32000 (80 m^3)	30000 (75 m^3)	30000 (75 m^3)	26400 (66 m^3)	24800 (62 m^3)	23600 (59 m^3)
		Total	41900	35700	33700	31700	32100	28300	26700	25500

Table 1 (d)

Cost benefit analysis for one hectare of Eucalyptus hybrid plantation (Including 3 coppice crops) at 2.5 m × 2 5 m.

Year	Plantation and maintenance of coppice (Rs)	Discounted @			Total benefits (Rs)	Discounted @		
		12%	15%	18%		12%	15%	18%
1	2	3	4	5	6	7	8	9
1	3280	2928	2852	2779	—	—	—	—
2	1764	1406	1334	1267	500	398	378	359
3	760	541	500	462	500	356	328	304
4	760	483	434	392	500	318	286	258
5	380	215	166	189	500	284	248	218
6	450	228	194	166	1500	760	648	555
7	450	203	169	141	1500	678	564	471
8	500	222	163	133	41900	16919	13697	11145
9	865	312	246	195	—	—	—	—
10	1355	436	335	259	500	161	123	95
11	1160	333	249	188	500	144	107	81
12	560	144	104	77	500	128	93	68
13	560	128	91	65	500	114	81	58
14	605	124	85	59	1300	266	183	128
15	525	96	64	44	1300	237	159	108
16	575	94	61	41	35700	5822	3812	2524
17	865	126	80	52	—	—	—	—
18	1355	176	109	69	500	65	40	25
19	1160	135	81	50	500	58	35	21
20	560	58	34	20	500	52	30	18
21	560	52	30	17	500	46	26	15
22	605	50	28	16	1300	107	60	34
23	525	38	21	12	1300	96	52	29
24	575	38	20	11	33700	2217	1176	633

(Contd ..)

1	2	3	4	5	6	7	8	9
25	865	51	26	14	—	—	—	—
26	1355	71	36	18	500	26	13	7
27	1160	54	26	13	500	23	11	6
28	560	23	11	5	500	21	10	5
29	560	21	10	4	500	18	9	4
30	605	20	9	4	1300	43	19	9
31	525	16	7	3	1300	39	17	8
32	575	15	6	3	31700	843	361	158
Total		8817	7:81	6768		30239	22566	17325

Sl. No.	Results	Discounting rate of interest		
		12%	15%	18%
1.	Net Present Value in Rs.	21,422	14,986	10,557
2.	Benefit/Cost Ratio	3.43	2.98	2.56
3.	Internal Rate of Return	Approximately 40%		

Table 1 (e)

Cost - Benefit analysis for one hectare of Eucalyptus hybrid plantation (Including 3 coppice crop) at 3 m × 1.5 m.

Year	Plantation and Maintenance of coppice (Rs.)	Discounted @			Total	Discouted @		
		12 %	15 %	18 %	Benefit (Rs.)	12 %	15 %	18 %
1	2	3	4	5	6	7	8	9
1	4097	3698	3562	3472	—	—	—	—
2	1960	1562	1482	1407	500	39	378	359
3	760	541	500	462	500	356	328	304
4	760	483	434	392	500	318	286	258
5	380	215	189	166	500	284	248	2:8
6	480	243	207	178	1700	861	735	629
7	450	203	169	141	1700	769	639	533
8	5 0	214	173	141	32100	12962	10493	8538

(Contd.)

1	2	3	4	5	6	7	8	9
9	967	249	275	218	—	—	-	—
10	1682	541	415	321	500	161	123	95
11	1335	383	287	216	500	144	107	81
12	560	143	104	77	500	128	93	68
13	560	128	91	65	500	114	81	58
14	630	129	89	62	1500	307	212	148
15	550	100	67	46	1500	274	184	125
16	600	93	64	42	28300	4616	3022	2000
17	967	141	90	58	—	—	—	—
18	1682	218	136	25	500	65	40	25
19	1335	155	93	57	500	58	35	21
20	560	58	34	20	500	52	30	18
21	560	52	30	17	5 0	46	26	15
22	630	52	29	16	1500	124	69	39
23	550	40	22	12	1500	110	60	33
24	600	39	21	11	26700	1757	922	502
25	967	57	29	15	—	—	—	—
26	1682	88	44	23	500	26	13	7
27	1335	62	30	15	500	23	11	6
28	560	23	11	5	500	21	10	5
29	560	21	10	4	500	18	9	4
30	630	21	9	4	1500	56	23	10
31	550	16	7	3	1500	50	20	9
32	600	16	6	3	25500	678	290	127
	Total	10089	8709	7754	Total	24776	18497	14280

Sl. No.	Results	Discounting Rate of Interest		
		12 %	15 %	18 %
1.	Net Present Value in Rs.	14,687	9788	6526
2.	Benefit/Cost Ratio.	2.45	2.12	1.84
3.	Internal Rate of Return.	Approximately 32%		

(b) *Plantations raised on farm lands in combination with agricultural crops.* The plantation cost in respect of Uttar Pradesh and Punjab/Haryana have been presented in Table 2. The cost of raising agricultural crop in U.P. and Punjab/Haryana have been shown in Table 2 (a) and Table 3 (a) & (b). The returns received by agriculture are shown in Table 2 (b) and Table 3 (c) respectively.

In this case the yield has been calculated in two different regions viz , U.P.—Tarai, and Haryana/Punjab. The spacing considered is 2.5 m × 2.5 m 3.0 m × 1.5 m, 4.0 m × 2.0 m and 6.0 m × 1.0 m and average yield at 8 year rotation has been taken into account of 106 m^3, 79 m^3, 78 m^3 and 116 m^3 and for 10 rotation 126 m^3, 99 m^3, 88 m^3 and 131 m^3 respectively. The yield figures (Under Bark volume) are based on the studies reported in U.P. Forest Bulletin No. 42 (Lohani, 1980) The returns from *Eucalyptus* plantation have been calculated @ Rs. 400 per m^3 (under bark standing volume). *Eucalyptus* is also being raised on bunds by the farmers at 2 m apart. This practice has also been considered and the results have been shown separately. In this case presuming the survival per cent at 85 the number of trees survived are taken as 170 per ha. The total returns have been calculated at 8 year and 10 year age considering one tree will fetch up price @ 90/- and Rs. 100/- respectively at 8 year and 10 year age (Bachan Singh, 1983).

The yield of agricultural crops has been considered as reported by various studies conducted on Agro-forestry in U.P. and Punjab/Haryana.

The returns for the agriculture produce have been calculated on the basis of prices fixed by the Government. The farmers in both areas are generally growing crops like paddy, wheat, sugarcane and the same have been considered in the present study.

Results of Analysis

Bund Planting. The farmer is cultivating agricultural crops throughout rotation. The costs and returns in different years have been discounted on 12, 15 and 18 per cent rates of interest for both areas (U P. and Punjab/Haryana) and have been shown in Table 2 (c) and Table 3 (d). It can be seen from Punjab/Haryana area that Net Present Value is maximum, i e Rs. 34,371 at the age of 10 years rotation on 12 per cent rate of interest. The same trend is also available in case of U.P. where the maximum Net Present Value is Rs. 22,556 as compared to 8 year rotation. This increasing trend is because of the cultivation of agriculture crop throughout the rotation. Benefit cost ratio with same rate of interest for Punjab/Haryana and U.P. is maximum i e. 2.32 and 1.60 at 8 year rotation. The farmers prefer planting on bunds because of no extra costs are involved on plantation and the effect of *Eucalyptus* on agricultural crops is also negligible.

Block Planting. The farmers are practicing agriculture upto 3rd year of plantations. The discounted costs and returns for each year for block planting raised at different spacing i.e. 2.5 m × 2.5 m, 3.0 m × 1.5 m, 4.0 m × 2.0 m and 6.0 m × 1.0 m have been shown in Table 4 for U.P. and Punjab/Haryana.

It has been found that in Uttar Pradesh, Planting of *Eucalyptus* with intercropping at 6.0 m × 1.0 m spacing after 8 year rotation with 12% interest, has given maximum Net Present Value (NPV) of Rs. 18,702. The Benefit Cost ratio (B : C) has also been found maximum i.e. 2.28. The NPV and B : C have however been found maximum at 10 year rotation for the same spacing. The Internal Rate of Return has been found maximum i.e. 96 and 87 per cent for 4.0 m × 2.0 m spacing at 8 and 10 year rotation respectively. This is because of variation in planting cost which is the lowest in 4.0 m × 2.0 m spacing.

In case of Punjab/Haryana, *Eucalyptus* raised at 6.0 m × 1.0 m spacing with intercropping at 8 year rotation also justifies its potential as in U.P. The maximum NPV and B : C was found to be Rs. 17,022 and 2.17 respectively. The maximum Internal Rate of Return i.e. 73 per cent was obtained in case of 4.0 m × 2.0 m spacing at 8 year rotation as compared to 63 per cent for 6.0 m × 1.0 m spaing.

On the basis of above discussion, it can thus be concluded that for raising *Eucaylptus* at spacing of 6.0 m × 1.0 m with a rotation of 8 years in combination with agricultural crops is economically viable for both areas i.e. U.P. and Punjab/Haryana.

The Internal Rate of Return was however higher in case of 4.0 m × 2.0 m spacing which is due to less expenditure on planting operations.

Conclusions

1. Raising of *Eucalyptus* without intercropping at 2.5 m × 2.5 m spacing with three coppice crops on 8 year rotation basis with 12% discount rate gave significantly higher net returns as compared to 3.0 m × 1.5 m spacing.

2. *Eucalyptus* raised on field bunds in U.P., Punjab/Haryana gave the highest Net Present Value at 10 and 8 year rotation with 12 per cent rate of interest as compared to *Eucalyptus* raised in block planting both with and without intercropping.

3. Planting of *Eucalyptus* in combination with agricultural crops at 6.0 m × 1.0 m spacing with 8 year rotation gave the highest Net Present Value and Benefit Cost ratio at 12 per cent rate of interest in both areas i.e U.P. and Punjab/Haryana.

4. The Internal Rate of Return was found to be higher for 4.0 m × 2.0 m spacing with intercropping at 8 year rotation in U.P. and Punjab/Haryana.

5. For small farmers planting of *Eucalyptus* on bunds is economically viable and is thus recommended. In this case the farmer will get extra income from *Eucalyptus* plantation without sacrificing the agriculture production which is his necessity for livelihood.

6. Cultivation of *Eucalyptus* with wider spacing between lines at 8 year rotation with agriculture on farm land is profitable.

Table 2

Per hectare cost (in Rs.) of different type of plantations in U.P. and Punjab/Haryana

Labour Rate ; Rs. 10/- per day in U.P. and Rs. 15/- per day in case of Punjab/Haryana.

Years	Category/Head of operations and works.	Bunds at 2 m apart (200 plants)		Block Planting 2 5 m×2.5 m (1600 plants)		3.0 m×1.6 m (2222 plants)		4 0 m×2.0 m (1250 plants)		6 0 m×1.0 m (1666 plants)	
		U.P.	Punjab Haryana	U.P.	Punjab Haryana	U P.	Punjab Haryana	U.P.	Punjab Haryana	U.P.	Punjab Haryana
1	2	3	4	5	6	7	8	9	10	11	12
1	*Preplanting (peration :*										
	(a) Boundary demarcation and alignment of the areas.	10	15	30	45	30	45	30	45	30	45
	(b) Digging of pits sized 45 × 45 cms.	60	70	680	560	667	778	375	438	500	583
	(c) BHC/Aldrex 10%	15	15	120	120	167	167	94	94	125	125
	(d) FYM incl. Transport and labour, @ 3 to 4 kgs per pit.	20	24	160	192	222	267	125	150	167	200
	(e) Filling of pits and mixing of BHC/Aldrex and FYM.	20	30	160	240	222	333	125	187	166	250
	Planting and Post-planting works.										
	(a) Cost of Polythene bag seedlings including loading/unloading and Transport nursery to planting spot.	150	150	1200	1200	1667	1667	938	938	1249	1249

(Contd.)

1	2	3	4	5	6	7	8	9	10	11	12
(b)	Planting charges.	20	30	160	240	222	333	125	187	167	250
(c)	Weeding :										
	(i) First weeding	30	48	240	384	333	533	187	300	250	400
	(ii) Second weeding	20	30	160	240	222	333	125	187	166	250
(d)	Watering or irrigation manually	50	60	*	*	*	*	*	*	*	*
(e)	Supervision and managerial work farmers will do himself. Watching by a family member.	—	—	—	—	—	—	—	—	—	—
	Total	395	472	2710	3221	3752	4456	2124	2526	2820	3352
II (a)	Replacement of casualities, 25% plants need to be replaced due to mortality.	30	40	240	320	333	445	187	250	250	333
(b)	Weeding	20	30	160	240	222	333	125	187	167	250
(c)	Fertilizers and applying thereof in two doses. Urea/Superphosphate	80	80	640	640	889	889	500	500	666	666
(d)	Irrigations manually.	50	60	*	*	*	*	*	*	*	*
(c)	Miscellaneous and other unforseeen expenses.	50	50	150	150	150	150	150	150	150	150
	Total	230	260	1190	1350	1594	1817	962	1087	1233	1399
III to X	Miscellaneous and other unforeseen expenses made every year.	50	50	150	150	150	150	150	150	150	150

* Watering/Irrigation cost included in the agricultural crop.

Table 2 (a)

Cost of agriculture crops (Kharif, Rabi and Sugarcane), while Eucalyptus planted in the Farm (U P.)

Rs. per hectare

Year	Head of works	On bunds			Block planting		
						Sugarcane	
		Kharif paddy crops	Rabi wheat crops	Total	Raddy grown earlier	Main crop	oppice crop
I to III	1. Preparation of land	282	573	855	282	519	—
	2. Seedlings/Seed	175	445	570	125	1816	—
	3. Transplanting/sowing	507	185	692	507	136	—
	4. Fertilizers	914	360	1274	914	1200	714
	5. Irrigations	312	494	806	312	593	593
	6. Interculture	519	148	667	519	308	729
	7. Plant Protection	105	147	252	105	346	—
	8. Harvesting	454	334	788	454	556	494
	9 Winowing/Threshing	173	723	896	173	—	—
	10. Transporting	98	75	173	98	660	905
	11. Land Revenue	35	35	70	35	70	70
	Total	3524	3519	7043	3524	6212	3505
IV	Total cost on the above items.	3516	3511	7027			
V	Total cost on the above items.	3498	3500	3998			
VI to X	Total cost on the above items.	3484	3490	6974			

Table

Cost/Benefit Analysis of Eucalyptus

Years	Cost Incurred on			Discounted at		
	Plantation crop (Rs.)	Agriculture crop (Rs.)	Total (Rs.)	12%	15%	18%
1	2	3	4	5	6	7
1	395	7043	7438	6640	6467	6303
2	230	7043	7273	5797	5499	5223
3	50	7043	7093	5048	4663	4317
4	50	7027	7077	4497	4046	3649
5	50	6998	7048	3999	3503	3080
6	50	6974	7024	3558	3036	2601
7	50	6974	7024	3177	2640	2205
8	50	6974	7024	2836	2296	1868
	Total			35552	32150	29246
9	50	6974	7024	2533	1996	1583
10	50	6974	7024	2261	1735	1341
	Total			40346	35881	32170

Rotation Age in Years	Rate of Interest 12	
	NPV	B : C Ratio
8	21367	1.60
10	22556	1.55

2 (c)

Plantation on Bunds in U.P. Tarai Labour rate Rs. 10/- per day

Benefits Received From			Discounted at			Remarks
Plantation crop (Rs.)	Agriculture crop (Rs.)	Total (Rs.)	12%	15%	18%	
8	9	10	11	12	13	14
—	10,450	10,450	9330	9086	8855	*Assuming that 85% or 170 trees survive and sold as standing @ Rs. 90 & 100 per tree after attaining an age of 8 and 10 years respectively. (Bachan Singh, PAU Ludhiana.)
—	10,450	10,450	8329	7901	7504	
—	10,450	10,450	7437	6871	6360	
—	10,364	10,364	6586	5925	5345	
—	10,052	10,052	5703	4997	4393	
—	9,802	9,802	4965	4237	3630	
—	9,802	9,804	4433	3684	3077	
*15300	9,802 (A)	25,102	10136	8206	6677	
			3958 (A)	3204 (A)	2607(A)	
Total			56919	50907	48542	
* —	9,802	9,802	3534	2786	2209	
17000	9,802	26,802	8127	6623	5119	
Total			62602	55314	49100	

In %

15		18		IRR (%)
NPV	B : C Ratio	NPV	B : C Ratio	
18757	1.58	16596	1.56	
19443	1.54	16930	1.52	

Table 2 (b)

Benefit recieved from Agricultural Crops grown within plantation of Eucalyptus in Uttar Pradesh Tarai

Rupees per ha

Years	Agricultural yield in bund planting					Agricultural yield in Block planting				
	Kharif crop		Rabi crop		Total	Kharif Crop		Sugarcane crop		Total
	Paddy (Qtl.)	Value (Rs.)	Wheat (Qtl.)	Value (Rs.)		Paddy (Qtl.)	Value (Rs.)	Yield (Qtl.)	Value (Rs.)	
1	40	5200	35	5250	10450	35	4550	—	—	4550
2	40	5200	35	5250	10450	—	—	650	7800	7800
3	40	5200	35	5250	10450	—	—	500	6000	6000
4	39 46	5180	34.56	5184	10364	—	—	—	—	—
5	38.47	5000	33.68	5052	10052	—	—	—	—	—
6	37.51	4876	32 84	4926	9802	—	—	—	—	—
7	37.51	4876	32.84	4926	9802	—	—	—	—	—
8	37 51	4876	32.84	4926	9802	—	—	—	—	—
9	37.51	4876	32.84	4926	9802	—	—	—	—	—
10	37.51	4876	32 84	4926	9802	—	—	—	—	—

Per qtl. price of Paddy, wheat and sugarcane is taken Rs. 130, Rs. 150 and Rs. 12 respectively.

Table 3 (a)

Cost of agricultural crops (Kharif and Rabi) in Punjab/Haryana within Eucalyptus as a Block planting

Labour Rate @ Rs. 15/– per day

Year	Sl. No.	Works and Operation	Kharif (Paddy) crop		Rabi (Wheat) crop		Total
			Unit	Amount (Rs.)	Unit	Amount (Rs.)	
1	2	3	4	5	6	7	8
I	1.	Preparation of land with Harrow/ cultivator for sowing	2 times	166	4 times	332	498
	2.	Application of suhaga	1 time	40	2 times	80	120
	3.	Farm yard manure	—	—	5 trolleys	300	300
	4.	Seed	75 kg	112	1 Qtl.	200	312
	5.	Sowing of seed	—	30	—	30	60
	6.	Application of Superphosphate	—	—	—	30	30
	7.	Superphosphate/Diamonia/Urea	1.25 Qtl.	195	1 Qtl.	240	435
	8.	Preparation of Khals/Bund	—	60	—	60	120
	9.	Weeding and Plant protection	Twice	375	Once	225	600
	10.	Watering the area undercrop and application of fertilizers.	3 times	250	3 times	250	500
	11.	Harvesting and stacking of crop	—	250	—	250	500
	12.	Threshing/Winowing	20 Qtl.	200	25 Qtl.	375	575
	13.	Loading/unloading and transport upto market	Rs. 3/Qtl.	60	Rs. 3/Qtl.	75	135
	14.	Land Revenue etc.	—	45	—	45	90
		Total	—	1793	—	2492	4275

(Contd...)

1	2	3	4	5	6	7	8
II	1.	All costs same as during I year on items I to II	—	1468	—	1987	3455
	2.	Winowing/Threshing	17 Qtl.	170	21 Qtl.	315	485
	3.	Loading/Unloading and carriage to market of Agricultural produce	Rs. 3/Qtl.	51	Rs. 3/Qtl.	63	114
	4.	Land Revenue etc.	—	45	—	45	90
		Total	—	1734	—	2410	4144
III	1.	All costs same as during II year in item No. 1	—	1468	—	1987	3455
	2.	Winowing/Threshing	13 Qtl.	130	16 Qtl.	240	370
	3.	Loading/Unloading and carriage to market of Agriculture produce	Rs. 3/Qtl.	39	Rs. 3/Qtl.	48	87
	4.	Land Revenue etc.	—	45	—	45	90
		Total	—	1682	—	2320	4002

Table 3 (b)

Cost of agriculture crops (Rabi and Kharif) grown within bund Planting in Punjab/Haryana

Unit : Rupees per hectare

Year	Works/Operation	Rabi (Wheat) crop		Kharif (Paddy) crop		Total
		Unit	Amount (Rs.)	Unit	Amount (Rs.)	
1	2	3	4	5	6	7
I to II	1. All crops same as in the case of Block Planting on items I to II	—	1468	—	1987	3455
	2. Winowing/Threshing. incl. labour	37.5 Qtl.	563	35 Qtl.	350	913
	3. Loading/Unloading and carriage to market	Rs. 3/Qtl.	112	Rs. 3/Qtl.	105	217
	4. Land Revenue	—	45	—	45	90
	Total	—	2188	—	2487	4675
IV	1. All expenses same as above on items 1 to 4	—	1513	—	2032	3545
	2. Winowing/Threshing. incl. labour	37.038 Qtl.	555	34.58 Qtl.	346	901
	3. Loading/Unloading and carriage to market.	Rs. 3/Qtl.	111	Rs. 3/ Qtl.	104	215
	Total	—	2179	---	2482	4661

(Contd...)

1	2	3	4	5	6	7
V	1. All expenses same as above on item I	—	1513	—	2032	3545
	2. Winowing/Threshing incl. labour	36.082 Qtl.	541	33.67 Qtl.	337	878
	3. Loading/Unloading and carriage to market	Rs. 3/Qtl.	108	Rs. 3/Qtl.	101	209
	Total	—	2162	—	2470	4632
VI	1. All expenses same as above on item I	—	1513	—	2032	3545
to	2. Winowing/Threshing incl. labour	35.189 Qtl.	528	32.84 Qtl.	328	856
X	3. Loading/Unloading carriage to market	Rs. 3/Qtl.	105	Rs. 3/Qtl.	98	203
	Total	—	2146	—	2458	4604

Table 3 (c)

Benefits (Quantity and Value) Received from Agricultural crops grown within Plantation of Eucalyptus Punjab/Haryana

Rupees per hectare

Year	Agricultural yield in Bunds planting area					Agricultural yield in Block planting area				
	Rabi crop		Kharif crop			Kharif crop		Rabi crop		
	Wheat (Qtls.)	Value (Rs.)	Paddy (Qtl.)	Value (Rs.)	Total value (Rs.)	Paddy (Qtl.)	Value (Rs.)	Wheat (Qtl.)	Value (Rs.)	Total value (Rs.)
1	37.5	5625	35	4550	10175	20	2600	25	3750	6350
2	37.5	5625	35	4550	10175	17	2210	21	3150	5360
3	37.5	5625	35	4550	10175	13	1690	16	2400	4090
4	37.038	5555	34.56	4493	10048	—	—	—	—	—
5	36.082	5412	33.68	4378	9790	—	—	—	—	—
6	35 189	5278	32.84	4269	9547	—	—	—	—	...
7	35.189	5278	32.84	4269	9547	—	—	—	—	—
8	35.189	5278	32.84	4269	9547	—	—	—	—	—
9	35.189	5278	32.84	4269	9547	—	—	—	—	—
10	35.189	5278	32.84	4269	9547	—	—	—	—	—

Per Quintal price of wheat and paddy is taken Rs. 150 and Rs. 130 respectively.

Table

Cost Benefit Analysis of Eucalyptus Plantation

Year	Cost incurred on			Discounted @ %		
	Plantation crop (Rs.)	Agriculture crop (Rs.)	Total (Rs.)	12	15	18
1	2	3	4	5	6	7
1	472	4675	5147	4595	4475	4361
2	260	4675	5935	3933	3731	3544
3	50	4675	4725	3362	3106	2875
4	50	4661	4711	2994	2693	2429
5	50	4632	4682	2656	2327	2046
6	50	4604	4654	2357	2012	1724
7	50	4604	4654	2105	1749	1461
8	50	4604	4654	1879	1521	1238
	Total			23,881	21,614	19,678
9	50	4604	4654	1678	1322	1049
10	50	4604	4554	1498	1150	889
	Total			27,057	24,086	21,616

Rotation age (yrs.)	Rate of Interest in percent		
	12		15
	NPV	B/C Ratio	NPV
8	31,681	2.32	28,064
10	34,371	2.27	29,864

3 (d)

on Bunds in Punjab/Haryana

Labour Rate Rs. 15/- per day

Benefits Received from			Discounted @ %			Remarks
Plantation crop (Rs.)	Agriculture crop (Rs.)	Total (Rs.)	12	15	18	
8	9	10	11	12	13	14
—	10175	10175	9084	8847	8622	Assuming that 85%
—	10175	10175	840	7693	7306	or 170 trees survive
—	10175	10175	7241	6690	6192	and sold as standing
—	10048	10048	6385	5744	5181	@ Rs. 90 per tree
—	9790	9790	5555	4866	4279	and Rs. 100 per tree
—	9547	9547	4836	4127	3536	after age of 8 and
—	9547	9547	4318	3589	2997	10 years respectively
15300*	9547 (a)	24847	10033	8122	6609	(Bachan Singh, PAU)
			3855 (A)	3121 (A)	2539 (A)	
—		Total	55562	49678	44722	
—	9547	9547	3342	2713	2152	
17,000	9547	26547	8545	6 60	5070	
		Total	61371	53950	47874	

	18		IRR (%)
B/C Ratio	NPV	B/C Ratio	
2.30	25,044	2.27	
2.24	26,258	2.21	

Table

Cost analysis of block plantations of Eucalyptus

States	Spacings (m)	Rotation age (yrs)	Sum of Discounted Costs @			Sum of Discounted	
			12%	15%	18%	12%	15%
1	2	3	4	5	6	7	8
Punjab/ Haryana	2.5 m × 2.5 m (1600 Plants)	8	14410	13730	13111	29973	26122
		10	14512	13810	13174	29076	24716
	3.0 m × 1.5 m (2222 Plants)	8	16885	15157	14489	25612	22592
		10	16987	15237	14552	25599	22047
	4.0 m × 2.0 m (1250 Plants)	8	13536	12884	12290	25450	22461
		10	13638	12964	12353	24183	20958
	6.0 m × 1 0 m (1666 Plants)	8	14566	13881	13254	31588	27430
		10	14668	13961	13317	29719	25210
U.P.	2.5 m × 2.5 m (1600 Plants)	8	14410	13748	13105	31670	26658
		10	14552	13828	13168	30773	25252
	3.0 m × 1.5 m (2222 Plants)	8	15703	14954	14278	27309	24128
		10	15805	15034	14341	27296	23583
	4.0 m × 2.0 m (1250 Plants)	8	13745	13061	12445	27147	23997
		10	13847	13141	12508	25880	22496
	6.0 m × 1.0 m (1666 Plants)	8	14583	13871	13230	33285	28966
		10	14685	13951	13293	31416	26746

4

with intercropping in Punjab, Haryana and U.P.

Unit : Rupees

Benefits @	Net-Present Value @			B/C Ratios			IRR (%)
18%	12%	15%	18%	12%	15%	18%	
9	10	11	12	13	14	15	16
22997	15563	12392	9886	2.08	1.90	1.75	6 46
21345	14564	10906	8117	2.00	1.79	1.62	49
2012·	8727	7435	5635	1.57	1.49	1.39	40
19282	8612	6810	4730	1.50	1.44	1.32	34
20018	11914	9577	7728	1.88	1.74	1.62	73
18442	10545	7994	6089	1.77	1.61	1.49	65
24061	17022	135 9	10807	2.17	1.97	1.81	63
21727	15051	11249	8410	2.02	1.80	1.63	48
24385	17220	12910	11280	2.19	1.94	1.86	77
22733	16221	11424	9565	2.11	1.82	1.72	62.5
21512	11606	9174	7234	1.74	1.61	1.50	51
20670	11491	8549	6329	1.72	1.52	1.44	42
21406	13402	10936	8961	1.97	1.83	1.72	96
19830	12033	9355	7322	1.87	1.71	1.58	87
25449	18702	15095	12219	2.28	2 08	1.92	75
23115	16731	12795	9822	2.14	1.91	1.74	60

SUMMARY

Increasing attention is being paid to raising large scale plantations of *Eucalyptus* spp under Agro-Forestry throughout India to meet the demand for firewood, small timber, poles, beams, paper pulp etc. A shift in the cropping pattern from agriculture to farm forestry has been experienced in the States of Uttar Pradesh, Punjab and Haryana. *Eucalyptus* has been planted by the farmers on field bunds, along field boundaries, in rows along water channels and in compact blocks in agriculture fields with variable spacings.

The present paper presents the results in respect of economic feasibility of *Eucalyptus* raised with or without agriculture on fields bunds and in blocks at varying spacings viz. 2.5 m×2.5 m, 3.0 m×1.5 m, 4.0 m×2.0 m and 6.0 m×1 0 m on farm lands. Cultivation of *Eucalyptus* at wider spacing in combination with agriculture crops at 8 years rotation ensures high economic returns.

कृषि-वानिकी के अन्तर्गत लगाए हुए युकेलिप्टस रोपवनों का अर्थशास्त्र

लेखक आर०एस० माथुर, के०के० शर्मा व एम०वाई० अंसारी

सारांश

ईंधनकाष्ठ, लघुकाष्ठ, बल्लियों, शहतीरों, कागज की लुगदी इत्यादि की मांग पूरी करने के लिए भारत में सर्वत्र कृषि-वानिकी के अन्तर्गत युकेलिप्टस प्रजातीय रोपवन बड़े परिमाण पर लगाने पर अधिकाधिक ध्यान दिया जा रहा है। उत्तर प्रदेश, पंजाब और हरियाणा में कृषि से कृषि-वानिकी की ओर फसल सज्जा में परिवर्तन होता अनुभव किया गया है। खेतों की मेंडों, खेतों की बाड़, पानी की नालियों के किनारे पंक्तियों में तथा खेती के दरम्यान निविड़ भूखण्डों में भिन्न-भिन्न फासले बीच में देकर किसानों ने युकेलिप्टस रोपण किया है।

प्रस्तुत अभिपत्र में कृषि के साथ या उसको साथ लिए बीना खेतों की मेंड़ों पर या भूखण्डों में भिन्न-भिन्न फासला जैसे 2.5×2.5 मी०, 3.0×1.5 मी०, 4.0×2.0 मी० और 6.0×1.0 मी० रख कर, खेतों में युकेलिप्टस उगाने की आर्थिक उपादेयता विषयक परिणाम प्रस्तुत किये गये हैं। आठ वर्ष का आवर्तन रखकर कृषि सस्य के साथ अधिक चौड़ा फासला उपयोग में लाना अधिक आर्थिक प्रत्याय दिलाना सुनिश्चित कर देता है।

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NITRATE ASSIMILATION IN LEAF BLADES OF *EUCALYPTUS*

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Introduction

Availability of nitrogen is the major factor, controlling protein synthesis in the plants. Nitrate is an important source of nitrogen in higher plants and it has to be reduced to the level of ammonia prior to its incorporation into amino acids, proteins and other nitrogenous compounds. An understanding physiology and biochemistry of its assimilation under forest conditions is utmost important to develop the selection criteria for the fast growing tree species.

Eucalyptus has almost all the desired qualities to serve as a cash crop in a short duration as compared to other tree species especially for the social forestry programme. It is fast growing, gives good timber, excellent pulping material, good fuel and provides protective cover to the soil in preventing erosion.

For better and rapid growth, it is most necessary that the plant should have efficient and concurrent carbon and nitrogen assimilatory systems within itself. Therefore, an attempt was made to study the *in vivo* nitrate reductase (NR) activity, a preliminary enzyme responsible for the utilization of soil nitrate in the *Eucalyptus* leaves. This communication will deal, presently with the standardization of the method for estimation of *in vivo* assay of the NR activity in the *Eucalyptus* leaves and the variation in the activity of the different leaves.

Materials and Methods

The leaf samples were collected from the *Eucalyptus* hybird trees standing near the potculture of Forest Influences Branch of Forest Research Institute and Colleges, Dehra Dun. The twigs containing the leaves were collected from 3-4 plants from three different heights, i.e. top, middle and lower part of the canopy every time, and brought to the laboratory. The leaves were separated from each twig, washed with water and excess of moisture were removed with the help of tissue papers. These leaves were chopped into small pieces with the scissor and assayed for the enzyme activity.

The preliminary samplings were done with the wide range of buffers, pH varying from 6 to 9 with four different substrate contentrations in two instalments, first 6 to 7.5 pH with four substrate concentrations i.e; 0.025, 0.05, 0.1 and 0.15 M and second 7.5 to 9 pH with three substrate concentrations except the last one. All pH solutions were maintained at

at 0.1 m concentration after testing. After the standardization of the enzyme activity in the pooled leaf samples (Table 1), individual leaves from the tip (Juvenile) to descending order (1 to 10) were also assayed for their NR activity. While standardizing the enzyme assay, sometimes it was observed to be too low, therefore, prior taking individual leaf samplings, the twigs were kept in incubation medium for some time as earlier described by Pokhriyal and Abrol (1980). The individual leaf data were calculated on the dry weight basis.

Table 1

In vivo nitrate reductase activity m μ (moles NO_3^- reduced g fr. wt^{-1} h^{-1}(under different conditions of buffer pH (phosphate, 0.1 m) and potassium nitrate concentrations.

pH of the phosphate buffer (0.1 m) in the incubation medium	Concentration of KNO_3 in the incubation medium/m			
	0.15	0.10	0.05	0.025
		I		
6.0	93.1 ± 4.04	95.6 ± 7.56	96.6 ± 6.19	109.8 ± 0.83
6.5	97.5 * 2.14	100.9 * 7.21	117.4 * 4.74	116.6 * 3.01
7.0	111.9 * 2.84	118.0 * 7.43	127.4 * 7.62	114.3 * 4.57
7.5	118.7 * 6.15	125.9 * 8.36	122.9 * 6.68	147.2 * 8.12
		II		
7.5	—	136.2 * 3.48	121.3 * 4.07	154.3 * 4.38
7.6	—	127.7 * 6.95	127.7 * 3.48	144.7 * 3.47
7.8	—	109.8 * 0.49	113.8 * 0.98	121.3 * 1.23
8.0	—	110.6 * 3.47	108.5 * 3.92	119.1 * 6.95
8.5	—	112.8 * 2.13	139.4 * 2.04	117.0 * 4.07
9.0	—	108.7 * 2.75	120.6 * 1.00	111.8 * 4.00

* Denotes ±

The method followed for assay of NR activity was similar to that of Kleppar *et al.* (1971) with some modifications (Nair and Abrol, 1977). The nitrite produced by the leaves was determined by the method of Evans and Nason (1953). All estimates were carried out atleast in triplicates. Total NR activity was calculated by multiplying the *in vivo* NR activity (m μ moles NO_3^- reduced g dry with wt^{-1} h^{-1}) by dry weight of each leaf. The standard error (±) values were calculated in each case.

Results

Preliminary investigation showed that high *in vivo* NR activity was obtained (154.3 ± 4.38 mμ moles NO_3^- reduced g fr, wt^{-1} h^{-1}), when buffer pH was 7.5 and the concentration of potassium nitrate in the incubation medium was 0.025 m. The activity declined with increase or decrease of the nitrate concentrations in the medium at this as well as with other pH solutions (Table 1).

Among individual leaves maximum activity (11(9 ± 45.9 m μ moles NO_3^- reduced g dry wt^{-1} h^{-1}) was observed in the newly emerged leaf and minimum (213 ± 18.3 m μ moles) in the tenth leaf. Almost similar types of results were also noticed in case of proline contents (unpublished Pokhriyal *et al*) Abrol *et al.* (1976), Grover *et al.* (1978) Chatterji *et al* (1980) and Pokhriyal and Abrol (1980), also reported higher enzyme activity in the upper leaf blades of wheat barley and bengal gram plants. The activity decreased as the age increased. This shows that the young leaves are more potential as far as NR activity is concerned as compared to the old ones. Total NR activity per leaf blade showed straight increase upto fourth leaf blade and it remained almost constant in 5th and 6th leaf blades also, thereafter it decreased steeply (Fig. 1). Fresh and dry weights of the leaf blades increased with the growth period upto seventh leaf stage after that it remained almost constant (Fig 2).

Discussion

Irrespective of the form in which nitrogen is available to the soil, it is taken up by the most of the plants in the form of nitrate (Bartholmew and Clark, 1965, and Lamb, 1967). Within the plants the nitrate is converted to nitrite by the enzyme NR. It is essentially assimilated by the shoot (Abrol and Nair, 1977). This is considered to be the limiting step in a series of reaction involved in nitrate assimilation and utilization of the soil nitrate. It is reduced to ammonia which is rapidly metabolised to form initially glutamine and then glutamate, the key amino acid involved in further biosynthesis of protein which in turn regulates various metabolic processes in the plants. The source of reductant (NADH) for this reaction and the supply of carbon skeletons as acceptors of ammonia for the synthesis of amino acids have been subject of intensive study.

It is well known that most of the nitrate taken up by the crop plants is assimilated in the leaves (Abrol *et al.* 1976) and upper leaf blades has significant role in the growth and development of plants (Chatterjee *et al*, 1980 and Pokhriyal and Abrol, 1980). Non-availability of nitrogen being the most limiting factor for protein synthesis within the plants. However, Hageman *et al* (1967) and Beevers and Hageman (1969) reported, that the activity of the NR, is the rate limiting in the conversion of nitrate to ammonia, could be considered as an index for the reduced nitrogen available in the plant for protein synthesis. Therefore, enhancement in the total biomass harvest has to be achieved by increasing nitrogen uptake by the plant and its translocation to different growing parts, which requires for an understanding of the basic mechanism of uptake and assimilation of nitrogen.

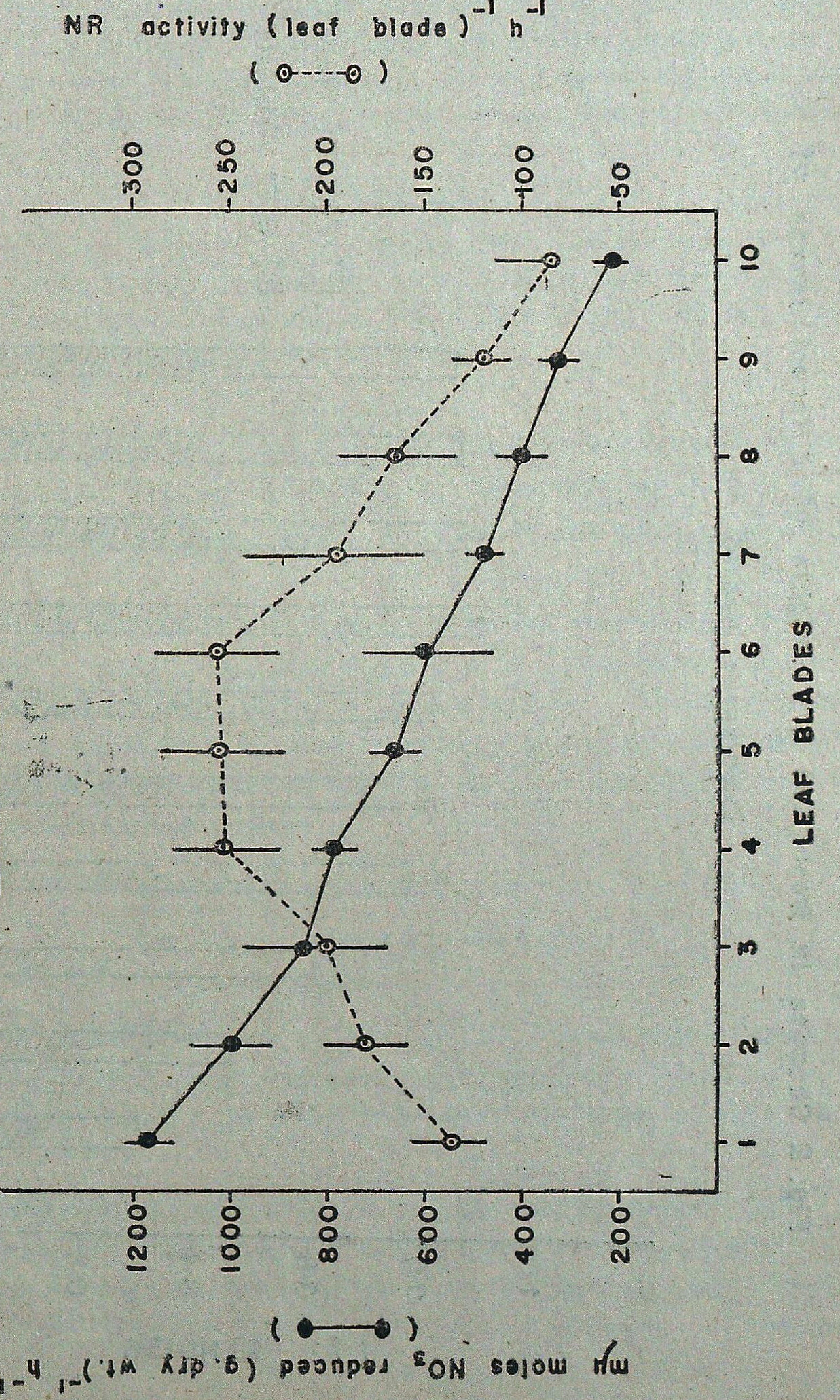

Fig. 1. Changes in NR activity of different leaves of *Eucalyptus hybrid*

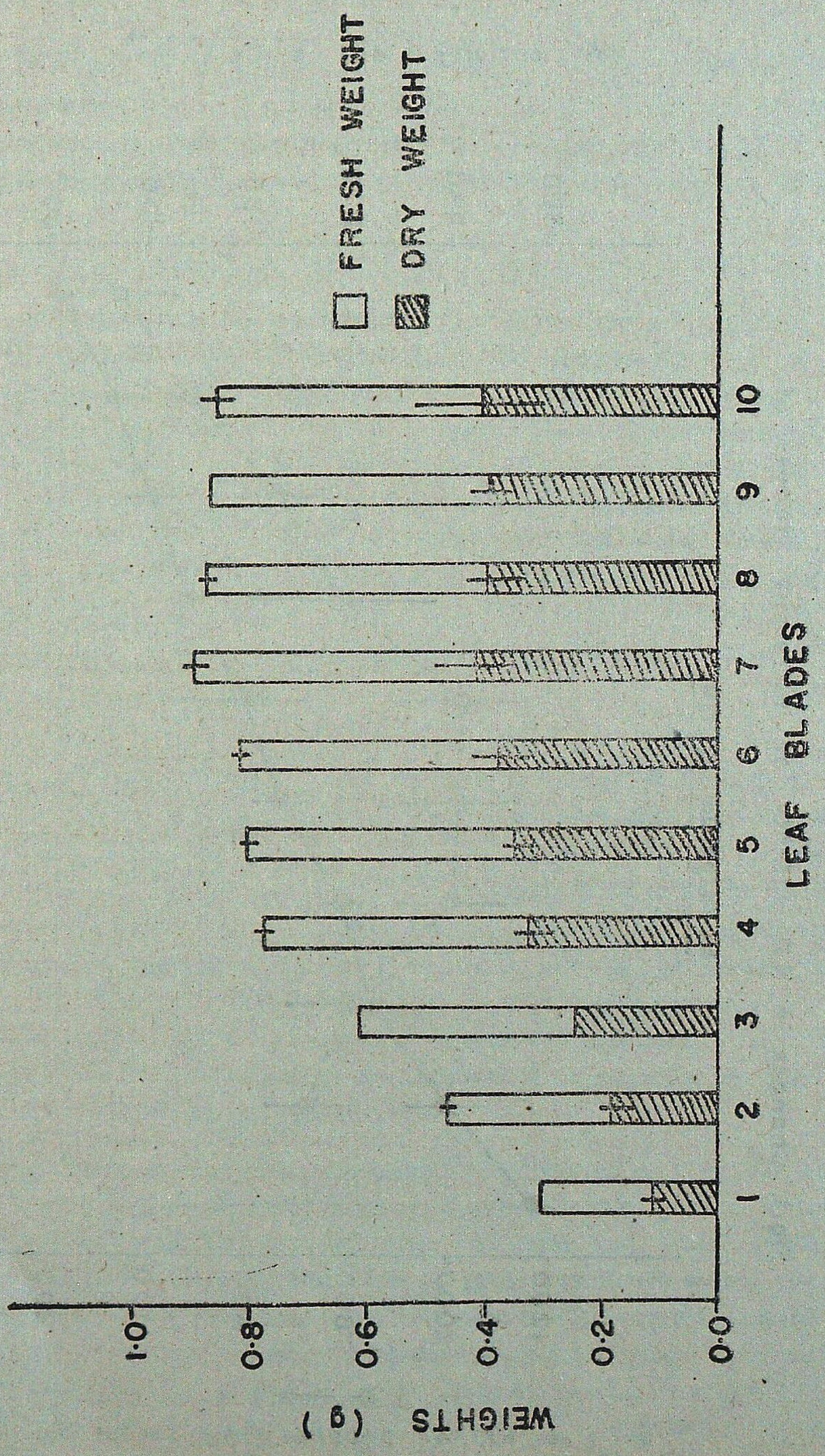

Fig. 2 Changes in fresh and dry weights of different leaves of *Eucalyptus hybrid*.

Nitrogen assimilatory pattern is well known in the agricultural crops. But unfortunately nothing much is known about the tree species. Probably because of the lacuna in the sampling procedure and representation of the data. Therefore, there is a great need to find out the enzymatic potential of individual plant parts in relation to nitrogen metabolism during the process of growth and development, so that it can be fully utilized, and their correlation with the biomass formation, especially in the fast growing tree species, like *Eucalyptus*.

Acknowledgements

The authors wish to thank Shri B.K. Subba Rao, Officer-in-Charge, Forest Influences Branch for the encouragement and co-operations during the course of this work and Dr. K. Gurumurthy, Officer-in-Charge, Plant Physiology Branch for providing facilities. Thanks are due to Mr. H.O. Nautiyal for technical help.

SUMMARY

The method for assay of *in vivo* nitrate reductase (NR) activity was standardised for for *Eucalyptus* leaf blades. The maximum activity (m μ moles NO_3^- reduced g dr wt^{-1} h^{-1}) was obtained with a 0.1 m phosphate buffer of pH 7.5 and 0.0:5 potassium nitrate concentration.

Among the ten individual leaf blades (in descending order from the tip) maximum NR activity (m μ moles NO_3^- reduced g dry wt^{-1}h^{-1}) was observed in the young (juvenile) ones, and further it dedreased with the increase in the age. Whereas, the total NR activity per leaf blade was higher in the middle order leaves (4th to 6th) and lowest in the tenth leaf. An increase in the fresh and dry weights of the leaves was observed upto seventh leaf, thereafter it remained almost constant.

युकेलिप्टस के पर्णफलकों में नाइट्रेट सात्मीकरण

लेखक टी०सी० पोखरियाल व ए०एस० रतूड़ी

सारांश

युकेलिप्टस के पर्णफलकों में सजीव नाइट्रेट प्रह्रासेय (in vivo nitrate reductase) का अनुमान करने की रीति को प्रतिमानित किया गया है। अधिकतम सक्रियता (एनओ$_3^-$ द्वारा घटाकर जी शुष्कभार$^{-1}$ एच$^{-1}$ मिलीमाइक्रोमोल्स में) पीएच 7.5 वाले 0.1 एम फास्फेट बफर 0.025 पोटाशि म नाइट्रेट संक्रेन्द्रण से प्राप्त हुई।

दस अलग-अलग पर्णफलकों में (नोक की ओर से घटते हुए अनुक्रम में) अधिकतम नाइट्रेट प्रह्रासेय (reductase) (एनओ$_3^-$ द्वारा घटाया जी शुष्कभार$^{-1}$ एच$^{-1}$ मिलीमाइक्रोमोल्स में) युवा (बाल) वृक्षों में पाई गई तथा वह उम्र बढ़ने के साथ कम होती चली गई। कुल नाइट्रेट प्रह्रासेय/सक्रियता प्रति पर्णफलक मध्यम अनुक्रम की पत्तियों में (चौथी से छठी) सब से अधिक और सब से कम दसवीं पत्ती में रही। पत्तियों के ताजे और शुष्कभार में वृद्धि सांतवीं पत्ती तक होती देखी गई जिसके बाद वह लगभग स्थिर हो गई।

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EVALUATION OF FUNGICIDES AND ANTIBIOTICS AGAINST *PESTALOTIOPSIS FUNEREA IN VITRO* CAUSING LEAF SPOT OF *EUCALYPTUS GLOBULUS**

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Introduction

Despite recent eruption of interest in healthy environment, far from pollution strain, fungicides and antibiotics continue to play an expanding role in plant protection. For each organism there is a border line concentration of these two above which the organism is sensitive and below which it is resistant. What is demanded in treatment is the attainment of a concentration of fungicides/ antibiotics at the site of infection that will inhibit the growth of the pathogen which is called as minimal inhibitory concentration Considerable work has been done by authors (Upadhyay & Dwivedi, 1977, 78, 79, 80; Upadhyay, Arora and Dwivedi, 1977, 80; Upadhyay & Arora, 1980 and Upadhyay, 1981–82) on the various major aspects of *Pestalotiopsis funerea* Desm. causing leaf spot disease of *Eucalyptus globulus* Labill. except chemical control of the pathogen. Keeping it in view, present investigation was undertaken *in vitro* to screen out a suitable concentration of fungicides as well as antibiotics for recommending chemical control trial in field.

Materials and Methods

Monosporic culture of *P. funerea* isolated from the leaves of *E. globulus* was maintained on Czapek-Dox + 0.05% yeast extract agar medium for further study.

Czapek-Dox + 0.5% yeast extract ($NaNO_3$, 2.0 g; K_2HPO_4, 1.0 g; $MgSO_4$, 0.5 g; KCl, 0.5 g; $FeSO_4$, 0.01 g; Sucrose, 30.0 g; 1000 ml distilled water) was used as a basal medium in the present study. Effect of different fungicides and antibiotics was studied by the poison food technique, during which desired quantities of them were incorporated in the molten nutrient agar medium The fungicides selected were diathane Z 78 (75% zineb + 25% inert carriers), phygon XL (2,3–Dichloro–1, 4–nephthaquinone 50% + inactive content 50%), cupramar Copper oxychloride, wettable powder containing 50% copper), difoltan 80W (captafol content (80%) and zincop; and antibiotics–mycostatin, griseofulvin, streptopenicillin, benzyl penicillin and streptomycin sulphate. These two were incorporated in the agar medium in such a calculated amounts as to give desired concentrations viz., 0.0031 to 0.6%: and 50 to 800 ppm respectively.

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* Part of Ph.D. Thesis of the author approved by Banaras Hindu University.

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Table

Per cent growth inhibition of P. funerea on nutrient agar (in vitro) supplemented

Concentration (%)	Fungicides									
	Diathane					Difoltan				
	Incubation period (h)					Incubation period (h)				
	24	48	72	96	120	24	48	72	96	120
1	2	3	4	5	6	7	8	9	10	11
0.6	100	100	100	100	100	100	100	100	100	100
0.4	100	100	100	100	100	100	100	100	100	00
0.2	100	100	100	100	100	100	100	100	100	100
0.1	100	100	100	100	100	100	100	100	100	100
0.5	100	100	100	100	100	89	89	89	89	89
0.025	100	100	100	94	91	85	85	85	85	85
0.012	100	100	94	84	60	85	85	85	85	85
0.006	81	56	36	35	27	79	79	79	79	79
0.003	79	39	34	37	28	44	44	44	44	44
Control (radial growth mm)	11	24	33	50	61	11	24	33	50	61

1

with different fungicides and their concentrations (Poison food technique)

Cupramar					Zincop					Phygon				
Incubation period (h)					Incubation period (h)					Incubation period (h)				
24	48	72	96	120	24	48	72	96	120	24	48	72	96	120
12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
100	100	100	100	95	100	100	100	100	100	100	100	100	100	100
100	100	90	91	83	100	100	100	100	97	100	100	00	100	100
100	89	81	83	67	100	100	100	96	96	100	100	100	100	100
100	83	79	72	61	100	100	100	95	94	100	100	100	100	100
100	80	74	65	57	100	100	100	88	77	100	100	100	100	100
62	47	40	36	24	100	90	69	51	42	100	100	96	96	96
23	27	25	22	21	61	38	37	30	22	100	100	95	94	88
20	22	16	16	11	35	25	36	28	18	100	96	95	93	87
10	12	13	10	8	24	16	25	13	11	100	95	92	88	87
11	24	33	50	61	22	24	33	50	61	11	24	33	50	61

Treatments are highly signficant indicated by the exceeding of the calculated value beyond the tabulated value after 124 h

For different fungicides 3011.85 > 3.93 with 4 and 36 degree of freedom at 1%

For different concentrations 5258.48 > 2.98 with 9 and 36 degree of freedom at 1%

Table

Per cent inhibition of P. funerea on nutrient agar (in vitro) supplemented

Concentration (ppm)	Antibiotics									
	Mycostatin					Streptopenicillin				
	Incubation period (h)					Incubation period (h)				
	24	48	72	96	120	24	48	72	96	120
1	2	3	4	5	6	7	8	9	10	11
800	100	100	100	100	100	80	70	67	61	52
600	100	100	100	100	100	31	20	28	18	12
400	100	100	100	100	100	26	20	25	19	11
200	100	100	100	100	100	24	13	22	16	5
100	100	100	100	100	100	19	9	20	14	3
50	100	100	100	86	82	13	2	12	10	0
Control (radial growth mm)	13	27	39	54	66	13	27	39	54	66

2

with different antibiotics and their concentrations (Poison food technique)

Benzyl penicillin					Griseofulvin					Streptomycin sulphate				
Incubation period (h)					Incubation period (h)					Incubation period (h)				
24	48	72	96	120	24	48	72	96	120	24	48	72	96	120
12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
39	26	30	23	13	53	43	42	38	31	100	100	48	43	29
25	17	22	17	8	50	43	41	37	31	57	42	44	33	35
15	11	20	14	6	50	41	41	36	29	50	40	42	30	23
13	12	20	12	4	48	39	41	35	28	40	26	33	22	14
12	12	20	9	4	47	46	39	34	26	30	25	33	17	11
11	11	18	9	2	45	37	39	35	21	14	23	20	12	4
13	27	39	54	66	13	27	39	54	66	13	27	39	54	66

There is highly significant variation among the treatments of antibiotics and their concentrations indicated by exceeding of the calculated value beyond the tabulated value.

Antibiotics = 28.04 > 4.22 with 4 and 24 degree of freedom at 1%.

Concentrations = 4.083 > 3.67 with 6 and 24 degree of freedom at 1%.

Fifteen ml of the above nutrient containing either a fungicide or an antibiotic was poured in a sterilized petridish. Agar disks of 6 mm size cut from the margin of a vigorously growing colony of the pathogen was placed over the solidified nutrient agar medium in centre of the dish and incubated for five days at 25 ± 1°C. Colony diameter was measured after 24, 48, 72, 96 and 120 of incubation and per cent inhibition was calculated compared to control (basal medium without any fungicides and antibiotics). The experiment was replicated three times to facilitate statistical evaluation of the data.

Results and Discussion

Table 1 depicts that phygon was most effective at all concentrations against the growth of the pathogen followed in order by difoltan, diathane, zincop and cupramar. Complete inbibition in growth of the pathogen was recorded with phygon and diathane at/ above 0 05%, difoltan at/above 0 1% and zincop at/above 0.6% concentrations, however, cupramar failed to inhibit growth completely even at 0 6% level of concentration. More than 85% inhibition was observed even at 0.003% (lowest coneentration) concentration of phygon where as it was below 10% with cupramar. Inhibition with diathane and difoltan was highly significant even at 0 025 and 0.006% concentrations respectively. Sankhala *et al.* (1973) and Bhowmik (1974) and Bhowmik (1974) also found diathane Z 78 to be most effective against the growth of the fungi studied by them. Similar results were obtained with difoltan by Agrawal *et al.* (1974).

It is evident from the Table 1 that all fungicides lost their inhibition value on successive prolongation of incubation period at lower concentrations except difoltan. Diathane, cupramar, zincop and phygon exhibited loss in inhibitory activity only at / below 0.025, 0.6, 0.4, 0.025% concentrations respectively, beyond which effect was found to be lethal. This loss in inhibition activity at lower concentrations of fungicides might be attributed to the capacity of adaptation or tolerance of the pathogen up to a particular level of concentration. The adaptation involves the decrease in permeability of fungal mycelial wall, detoxication of fungicides by biological conversion and decreased affinity between the chemical and the reactive site, circumvention of the blocked site by operation of an alternative pathway or compensation for the effects of the inhibitors (Dekker, 1976). Mathur *et al.* (1971) and Parry and Wood (1958, '59) also found that pathogen developed capacity of adaptation when grown on media containing concentrations of toxic materials. Difoltan was not found to loose its toxicity on increasing incubation period. Inoculum discs from higher concentrations of phygon, zincop, diathane and difoltan when transferred to the fresh nutrient agar did not resume growth which showed their fungicidal effects at that concentration. However, growth was found to resume in case of cupramar, thereby showing its fungistatic activity only.

Table 2 showed that mycostatin was found to be most effective followed in descending order by streptopenicillin, griseofulvin, streptomycin sulphate and benzyl penicillin.

Complete inhibition was recorded at all concentrations of mycostatin except at 50 ppm where it was reduced to be 82% after 120 h of incubation. Growth was not found to resume when inoculum disk was transferred from treated nutrient agar to fresh one, there byshowing its fungicidal activity.

Griseofulvin exhibited 31% inhibition at 800 ppm (highest concentration) whereas it was only 21% at 50 ppm (lowest concentration). Increasing concentrations of griseofulvin was not found to be significantly effective in relation to growth inhibition. Loss in inhibitory action was observed at all concentrations with the increase of incubation period which suggested it to be little fungistatic in nature. Brian (1949) and Ayton (1956) suggested that griseofulvin interferes with the synthesis and organization of cell wall materials. McNall (1960) has suggested that griseofulvin may also interfere nucleic acid metabolism.

29 and 4 per cent inhibition was recorded at 800 (highest) and 50 (lowest) ppm concentrations of streptomycin sulphate respectively. No significant difference in growth inhibition was observed with the increase of concentration. Loss in inhibitory action was noted at all concentrations on increasing incubation. It is well known that stroptomycin caused a variety of effects including damage to cell membrance, inhibition of protein synthesis and breakdown of RNA (Newton, 1965).

Streptopenicillin was not effective at lower concentration (50 ppm), while at higher concentration (800 ppm) 52% inhibition was recorded. However, inhibition was not significant even at 600 ppm. Singh (1975) reported streptopenicillin activity at higher concentrations only. Loss in inhibitory action was observed at all concentrations with the increase of incubation.

Benzyl penicillin was found to be least effective and insignificant as only 13% inhibition was observed even at highest concentration (800 ppm). Newton (1965) concluded that benzyl penicillin inhibited the enzymes responsible for wall synthesis.

Acknowledgements

A grant from CSIR in the form of Senior Research Fellowship is gratefully acknowledged. Thanks are due to Professor R S. Dwivedi for encouragements and to the Head, Department of Botany, Banaras Hindu University for laboratory facility.

SUMMARY

Effect of various fungicides and antibiotics on the growth of *Pestalotiopsis funerea* Desm. causing leaf spot of *Eucalyptus globulus* Labill was studied. Amongst the fungicides, phygon XL was found to be most effective followed in order by difoltan 80 W, diathane Z78, zincop and cupramar All of them exhibited loss in their inhibition value on successive prolongation of incubation at lower concentrations except difoltan Out of the five antibiotics used, mycostatin proved to be most detrimental followed by streptopenicillin griseofulvin, streptomycin sulphate and benzyl penicillin

Key Words : *Pestalotiopsis funerea*, **fungicides, antibiotics,** *Eucalyptus globulus.*

युकेलिप्टस ग्लोबुलस में पर्ण लांछन रोग उत्पादक पेस्टालोटियाप्सिस फ्यूनेरिया इन वाइट्रो के विरुद्ध कवकनाशियों और जीवाणुनाशियों का मूल्यांकन

लेखक राजीव के० उपाध्याय

सारांश

युकेलिप्टस ग्लोबुलस लेबिल में पर्ण लांछन रोग उत्पन्न करने वाले पेस्टालोप्टियाप्सिस फ्यूनेरिया डेस्म० की वृद्धि के विरुद्ध कुछ कवकनाशियों और जीवाणुनाशियों के प्रभाव का अध्ययन किया गया। कवकनाशियों में पाइगन XL सर्वाधिक प्रभावशाली रहा जिसके पश्चात् क्रम से आयफोल्टन 80 डब्लू, डायमेन जेड् 78, जिनकोन और क्यूपरामार रहे। डायफोल्टन को छोड़ सभी कवकनाशियों में संकेन्द्रण मात्रा घटाने पर अधिक समय तक रोग रोधन करने की रोधन शक्ति में कमी आती दिखाई दी। प्रयुक्त किए गऐ पांच जीवाणुनाशियों में से मायकोस्टोटिन सबसे अधिक सहारक सिद्ध हुआ जिसके पश्चात क्रम से स्ट्रेप्टोपेनिसिलिन, ग्रीसियोफुल्विन, स्ट्रोप्टामाइसिन सल्फेट और बेजाइल पेनिसिलिन रहे।

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STUDIES ON THE INHIBITORY EFFECTS OF *EUCALYPTUS* (HYBRID) LEAF EXTRACTS ON THE GERMINATION OF CERTAIN FOOD CROPS

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Introduction

The cultivation of *Eucalyptus* (hybrid) is gradually spreading to more and more areas in the country. Small farmers having few areas of marginal land are switching over to *Eucalyptus* cultivation since they find it more profitable than growing Ragi, Jowar or other day land crops. This trend is more pronounced under dry land agriculture where the return from the traditional food crops is very meagre. At the same time several farmers are expressing concern about the harmful effects of *Eucalyptus* trees on cultivable lands and standing crops. It is generally believed that *Eucalyptus* leaf litter makes the soil toxic for seed germination and plant growth and thereby reducing the yield potential of a particular crop.

The failure of herbaceous crop plants to grow under or near trees like *Walnut Black locust, Ailanthus altissima, Juneperus, Pine, Eucalyptus globulus* and *Eucalyptus camaldulensis* has been reported by several workers and is attributed to allelopathic effect of these trees (Del Moral and Muller 1969). The genus *Eucalyptus* has long been known to produce several volatile terpenes and several of them have been shown to be toxic to seed germination and seedling growth of numerous species of plants (Del Moral and Muller 1970). Fresh leves of *Eucalyptus camaldulensis* are found to produce large amounts of several volatile terpenes that are toxic to plant growth (Del Moral and Muller, 1969, 1970). A pronounced paucity of herbaceous plants was observed in planted forests of *Eucalyptus microtheca* is central Iraq in comparison with under story in adjascent *Cusuarina cunninghamiana* stands. Investigations revealed that the reduction was not due to soil moisture, nutrient elements and shading, on the otherhand leaf extracts, decaying leaves and soil collected under *Eucalyptus* canopies inhibited seed germination and seedling growth of associated species. In subsequent research three volatile inhibitors, and five water soluble inhibitors were found to be produced by *Eucalyptus* leaves (Al-Mousawi and Al-Maib, 1976), which inhibited germination of seeds.

Studies were therefore, conducted to findout the effect of leaf extracts of *Eucalyptus* (hybrid) tree on the germination and growth behaviour of some important dryland food crops.

Materials and Methods

One hundred leaves from an adult *Eucalyptus* (hybrid) tree were picked up at random, chopped and put in 250 ml of hot water (80°C) for fifteen minutes. The extract was decanted

and diluted five times. Hundred seeds of different crop plants (Table 1) were sown in seed pans and the pans were soaked with water. 100 ml of the diluted aqueous extract was applied to each pan at a time for three days. Observations on germination was recorded from third day upto tenth day from sowing and after twenty days growth behaviour, root and shoot lenght and dry weights were recorded. Seeds were simultaneously sown in petridishes lined with blotting papers under laboratory conditions. The blotting paper was thoroughly soaked with aqueous exctract after putting the seeds for germination and fed with small quantities of the extract for three days.

Results and Discussion

Germination. Inhibitory effect of the leaf extracts on seed germination was more pronounced under laboratory conditions than in the field Both treated and control seeds germinated normally in the field but the process was delayed by two to three days in the laboratory. The delay may be attributed to accumulation of toxic inhibitors over a period of time. Normal germination in the field may be due to dilution and leaching of some of the inhibitors due to watering. Germination percentage was low in most of the treatments compared to control. Interestingly percentage of germination increased in treated harse gram, green gram and cowpe. This indicates that the leaf extracts may have some stimulatory effect on some species of plants.

Growth of seedlings. Seedlings from the treated seeds in the petridishes died out few days after germination Seedling mortality was highest in Tur followed by coriander and beans. Though other crop seedlings survived they became stunted and chloratic. Seedlings in the field were stunted and chloratic for 15 to 18 days of growth and then recovered. The recovery may be attributed to leaching of toxins due to regular watering. Reduction in toxicity of *Eucalyptus* leaf litter after the advent of rains due to leaching has been observed by Rice (1974).

Shoot length was much reduced in most of the treatments, but the reduction was not significant compared to control. Marked reduction in root length was noticed in most of the seedlings and it was maximum in wheat seedlings. Root hair formation was completely inhibited in gingilly seedlings. The values for dry weight in all the treatments were consistently lower than in control indicating reduced growth and vigour in early stages of growth.

The studies indicate that the toxic substances added to the soil through the leaf litter remain for a long time in low rainfall areas and will have inhibitory effect on seed germination of crop plants The inhibitory effect will be minimised once the toxins are leached out by rains. It may be said that no crop can be grown successfully near *Eucalyptus* trees in low rainfall areas, where there is every chance of toxic substances remaining in the soil for a long time.

Table 1

Effect of aqueous leaf extract of Eucalyptus hybrid on different crop plants

Plant	Sps.	Germination (%)	Shoot length (cm)	Root length (cm)	Mortality (%)	Germination (%)	Shoot length (cm)	Root length (cm)	Dry wt/pan (100 seeds) (gm)
Ragi	T*	80	1.7	2.6	48	82	7.7	7.1	1.5
	C**	80	2.5	4.5	—	82	8.6	6 5	3.0
Wheat	T	76	5.8	5.5	56	92	17.3	8.5	6.0
	C	84	9.4	10.7	—	91	20 4	17.3	6.5
Bajra	T	44	4.1	4.2	12	69	14.2	9.7	2.0
	C	52	6.3	3.9	—	75	15.9	11.1	3.5
Fodder	T	52	3.6	3.4	28	52	15.2	11.6	2.5
Jowar	C	52	6.9	6.6	—	83	16.1	11.3	5.0
Horse	T	80	4.7	1.7	36	56	6.2	6.0	7.0
gram	C	72	5.9	3.1	—	60	7.5	7.3	7.0
Green	T	99	3.9	2.0	40	92	10.2	8.8	6.5
gram	C	82	5.0	3.5	—	84	10.1	11.7	9.0
Cow-	T	80	5.5	3.0	64	66	15.6	11.3	14.0
pea	C	76	5.4	3.4	—	84	6.0	15.0	15.0
Beans	T	76	4.0	3.0	74	74	13.7	12.3	33.0
	C	80	4.8	3 6	—	86	13.4	14.9	30.0
Bengal	T	42	5.3	2.5	66	34	13.2	13.2	34.0
gram	C	50	4.6	3.8	—	40	14.5	14.3	25.0
Tur	T	60	1.6	2 4	100	56	10.1	8. 5	8.0
	C	84	2.3	3.1	—	66	11.6	11.0	10.0
Cori-	T	4	3.0	2.5	90	7	2.5	2.8	2.1
ander	C	65	3.2	2.8	—	35	8.0	7.5	3.0
Ging-	T	92	3.2	1.0	20	75	7.2	6.9	2.0
illy	C	92	5.4	6.0	—	80	6.4	7.6	2.0

T*—Treated
C**—Control

SUMMARY

Investigations were carried out to study the effect of *Eucalyptus* (hybrid) leaf extracts on the germination and other growth parameters of selected dry land food crops. The results revealed that the leaf extracts inhibit germination of crop seeds to a certain extent Overall growth rate of seedlings was also reduced in all the treatmsnts compared to control. Heavy mortality of the seedlings and reduced vigour under laboratory conditions indicated that the accumulation of toxic substances is harmful to the growth of seedlings of crop plants. Reduction in vigour and growth rate in the early stages of growth was observed in the field grown seedlings but their gradual recovery indicated that once the inhibitory substances are leached out from soil the harmful effects are minimised. It may not be possible to grow food crops successfully near *Eucalyptus* plantation in areas with low rainfall where there is always a possibility of accumulation of toxic substances in the soil from the leaf litter.

कतिपय अन्न फसलों के अंकुरण पर (संकर) यूकेलिप्टस के पर्ण निस्सार के बाधक प्रभाव का अध्ययन

लेखक एन० स्वामीराव व पी० चन्द्रशेखर रेड्डि

सारांश

कुछ चुनी हुई असिंचित भूमि में होने वाली फसलों के अंकुरण तथा अम्य वृद्धि परिमाणों पर [संकर] यूकेलिप्टस के पर्ण निस्सार के प्रभावों का अध्ययन करने के लिये अन्वेषण किए गए। परिणामों से पता चला कि पर्ण निस्सार कुछ सीमा तक फसलों के बीजों के अंकुरण को बाधित करता है। कुल मिलाकर पौधों की बढ़ने की दर नियामक के मुकाबले में सभी उपचारित पौधों में घटी। प्रयोगशाला दशाओं में पौधों के भारी मरण और घटती/हुई ओजस्विता से संकेत मिलता है कि विपैले तत्वों का एकत्र होना अन्न पौधों की बढ़वार के लिए हानिकारक है। वृद्धि की आरम्भिक अवस्था में ओजस्विता और वृद्धि गति में कमी खेत में उगे पौधों में भी देखी गई परन्तु बाद में उनके संभल जाने से संकेत मिलता है कि बाधक तत्वों के एक बार घुल कर मृदा से निकल जाने पर हानिप्रद प्रभाव न्यूनतम रह जाते हैं। यूकेलिप्टस रौपवनों के पास ऐसे क्षेत्रों में जहां वर्षा कम होती है तथा जहां पत्तियां गिरने से पर्णास्तरण से विषैले तत्वों के जमा होने की सदा संभावना है अन्न की फसलें सफलतापूर्वक उगाना संभव नहीं होगा।

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GAZETTE NOTIFICATIONS

F.R.I. GAZETTE

The President, Forest Research Institute and Colleges, Dehra Dun has been pleased to appoint Km. Laxmi Pangtey, Research Assistant Grade I in the F.R.I & Colleges, Dehra Dun to the Post of Research Officer in Forest Soil Vegetation Survey, F.R.I. & Colleges, Dehra Dun with effect from the forenoon of 29th December, 1983 on the terms and conditions mentioned in this office Memo. No. A. 12025/1-33/82-Ests-III/I dated 28th December, 1983, until further orders.

ANDHRA PRADESH GAZETTE

On repatriation from M/s. A.P. Paper Mills Limited the services of Shri P.L. Maredy, I.F.S., Conservator of Forests are placed at the disposal of the A.P. Forest Development Corporation for a period of one year.

In supersession of the orders issued by the Chief Conservator of Forests in his proceedings cited, the Government place the services of Shri P. Shivaji, Assistant Conservator of Forests at the disposal of A.P. Forest Development Corporation initially for a period of one year.

HARYANA GAZETTE

The following officers have been promoted to State Forest Service and posted as written against each :

1. Shri Bhagat Ram, HFS, Attached Officer, Kurukshetra Forest Division.
2. Shri Uma Shankar, HFS, Attached Officer, Production Circle, at Chandigarh.
3. Shri Phool Chand, HFS, Attached Officer, Research & Training Division, Pinjore.
4. Shri Rajinder Singh, HFS, Attached Officer, with Director Forest Development Board at Chandigarh.
5. Shri Meher Singh, HFS, Attached Officer, West Circle, Hissar.
6. Shri Same Ram, HFS, Attached Officer, Bhiwani Forest Division at Bhiwani.
7. Shri Mahabir Parshad, HFS, Attached Officer, South Circle, Gurgaon.
8. Shri R.K. Sharma, HFS, (already promoted) now posted as Attached Officer, Research & Training Division, Pinjore.

KARNATAKA GAZETTE

Shri N. Sampangi, IFS., on return from leave is appointed with immediate effect and until further orders as Nodal Officer in the Office of the Chief Conservator of Forests (General), Karnataka, Bangalore.

Orders issued in Notification No. 168 SFP 82 dated 10/6/83 placing the services of Shri N. Sampangi, IFS., at the disposal of the Government of India for appointment as Joint Director, Forest Survey of India, Central Zone, Nagapur, are hereby cancelled.

NEWS & NOTES

The Akhil Bhartiya Vaniki Sahitya Puraskar Yojana—1983

Shri A.P. Dwivedi an I F.S. Officer of Bhopal has been declared winner of Shre.htha Lekhan Puraskar of Rs. 5,000/- for his Hindi book "Vana Vardhan Ke Siddhanta". Uttam Lekhan Puraskar of Rs. 3,000/- has gone to Shri Laxman Singh Khanna of Dehra Dun for his book "Vana Vardhan". Sarahniya Lekhan Puraskar of Rs. 1,000/- has been won by "Valmiki Ke Vana Aur Vriksha" a book written jointly by Shri G.S. Trivedi and Km. Savita Bhatt of Dehra Dun.

Under Lekh Puraskaras, the first prize of Rs. 500/- has gone in favour of article "Cosar Bhumi Men Safal Vriksharopan" to S/Shri Virendra Chandra and Naresh Chandra of Lucknow. The winner of the second prize of Rs. 350/- is Shri B.R. Varma of Dehra Dun for his article "Mourya Kal Men Vana Aur Vaniki'. The third prize of Rs. 200/- has been won by Shri Roopnarayan Kabra of Jobner, (Rajasthan) for his article "Manava Kee Seva Men Krishi Vaniki Evam Samajik Vaniki". Consolation prize of Rs. 100/- has gone to the article "Neem Lagaiye" of Shri V.S. : aksena of Ajmer.

The aforesaid awards will be presented to their winners in the forthcoming Convocation of Forest Colleges at Forest Research Institute and Colleges, Dehra Dun at the end of March, 1984.

FRI Publications

FOREST RESEARCH INSTITUTE AND COLLEGES, DEHRA DUN

Indian Forest Bulletins

No. 275—*Silvics.* Environmental effects of forest in India, by R.C. Ghosh, O.N. Kaul and B.K. Subba Rao. (Symbol No. PFRI. 188) Price Rs. 3.10 or £ 3.36 or $ 1.12.

Indian Forest Records

Vol. 3, No. 1-Wood Anatomy. Studies on the variation in Wood quality of *Eucalyptus tereticornis* Sm. trees grown in different plantations, Part-I—Wood specific gravity, by S.K. Purkayastha, S.P. Agarwal, R.D. Tondan and Laxmi Chauhan. (Symbol No. PFRI. 190). Price Rs. 5.50. or £ 0.64 or $ 1.98.

Other Publications

Timber Engineering Manual, Part III—Theory and practice of Timber lemella frames (Design, fabrication and erection techniques), by N.J. Masani. (Symbol No. PFRI. 176) Price Rs 22.00 or £ 2.56 or $ 7 92.

Indian Woods : Their identification, properties and uses, Vol. IV-Myrtaceae to symplocaceae, by S.K. Purkayastha (Symbol No. PFRI. 177) Price Rs. 145.00 or £ 16.91 or $ 52.20.

Field indentification of fifty important timbers of India, by K. Ramesh Rao & K.B.S Juneja (Reprinted 1983) (Symbol No. PFRI. 197) Price Rs. 10.00 or £ 1.17 or $ 3.60.

Abridged glossary of technical terms (For use in Forest Colleges). (Reprinted 1983). (Symbol No. PFRI. 193) Price Rs. 9.00 or £ 1 05 or $ 3.24.

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2. **The Deputy Conservator of Forests (Depot Division) Andamans Govt Timber Depot, 3-A, 2nd Floor, Auckland Place, Calcutta—17.**

3. **The Assistant Conservator of Forests, (Depot Division) Andamans Govt. Timber Depot, Marshalling Yard, Port Trust, MADRAS**

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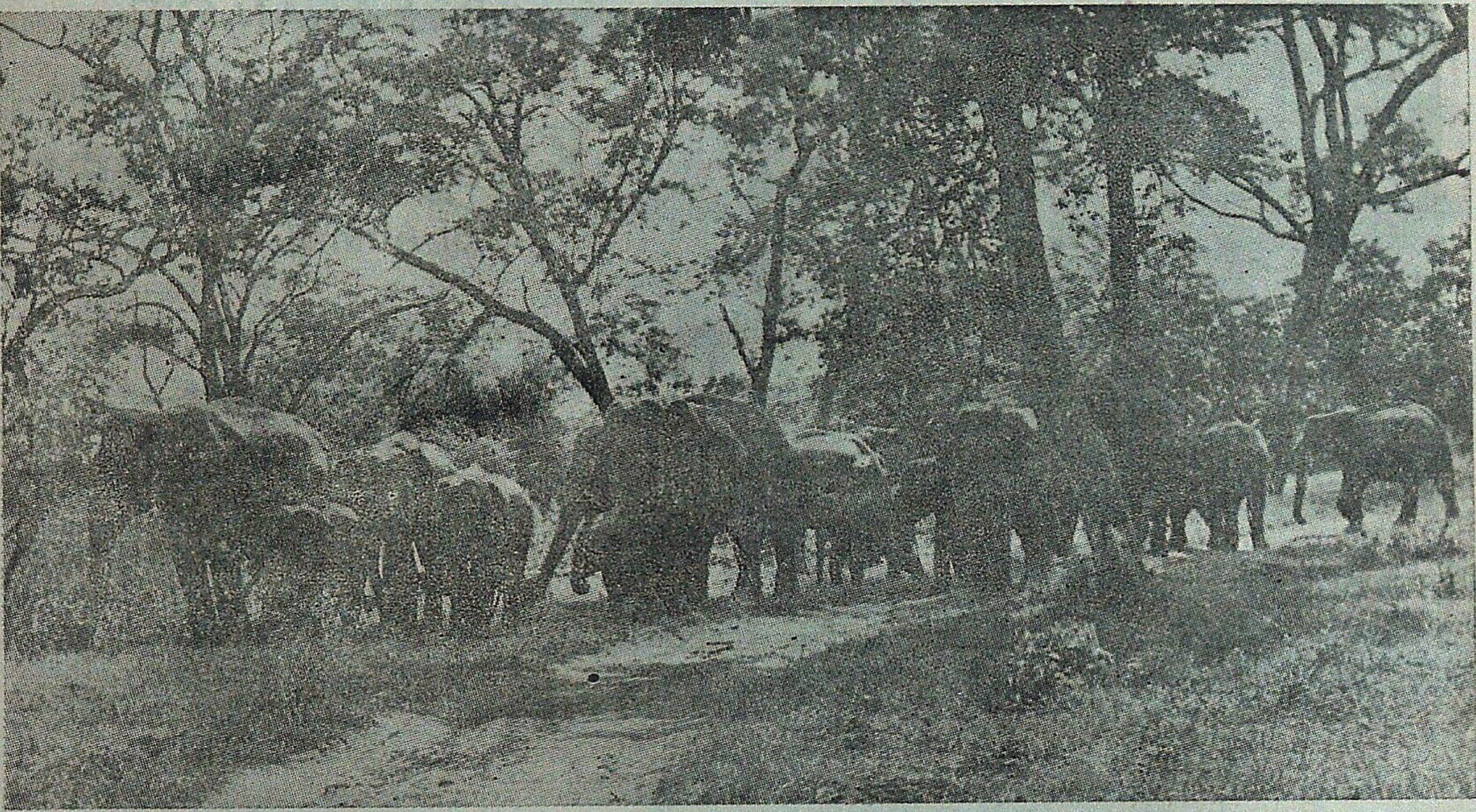

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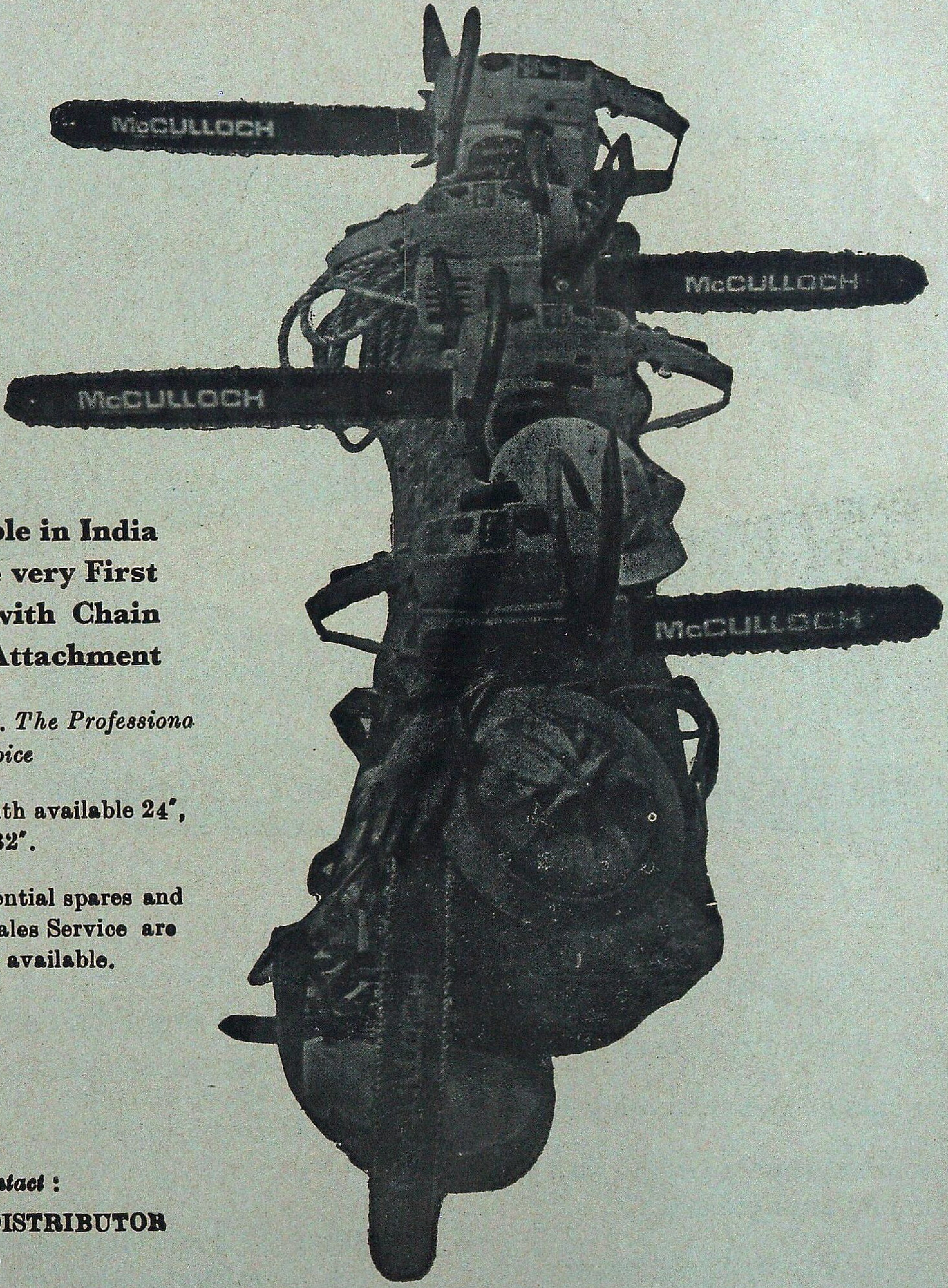

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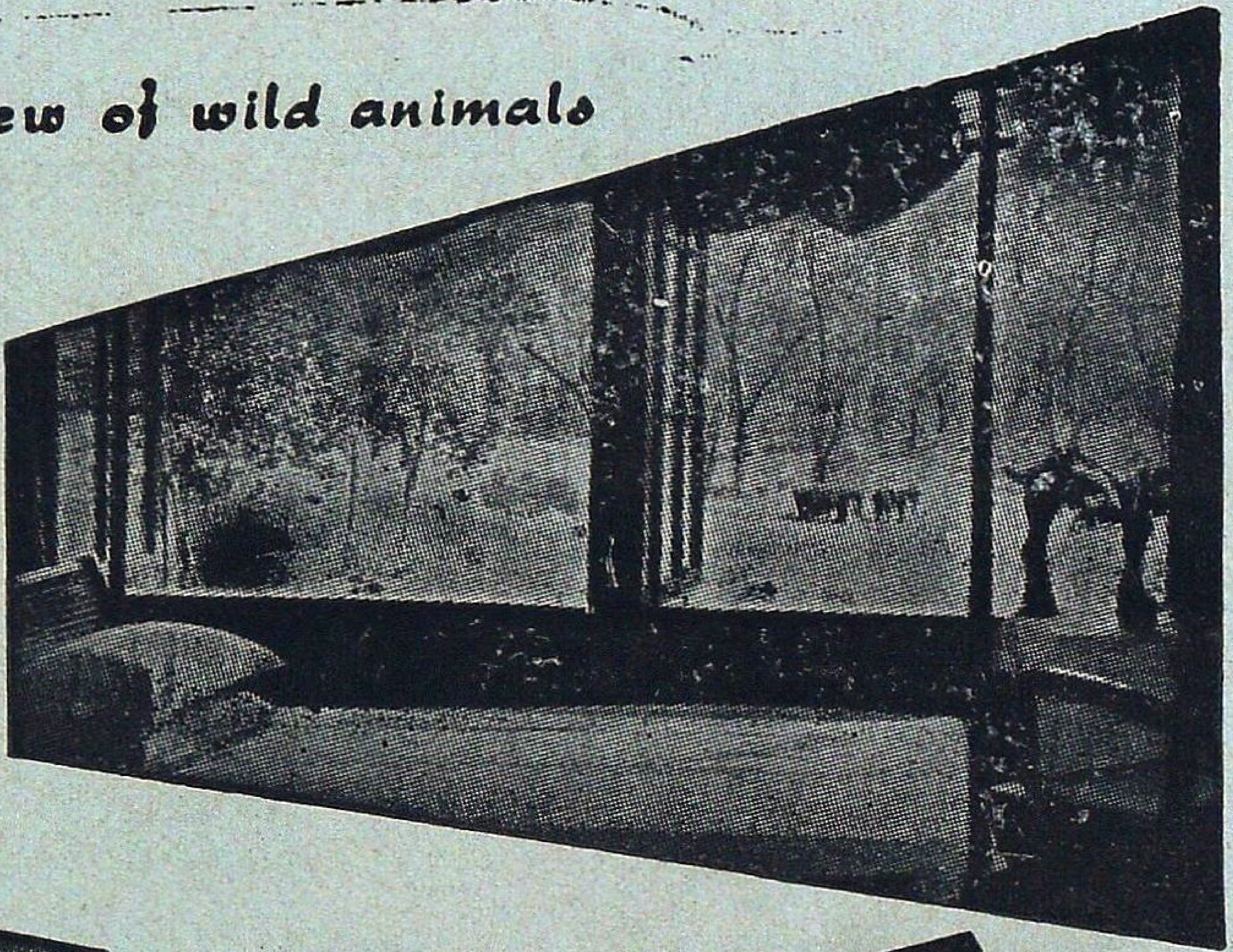

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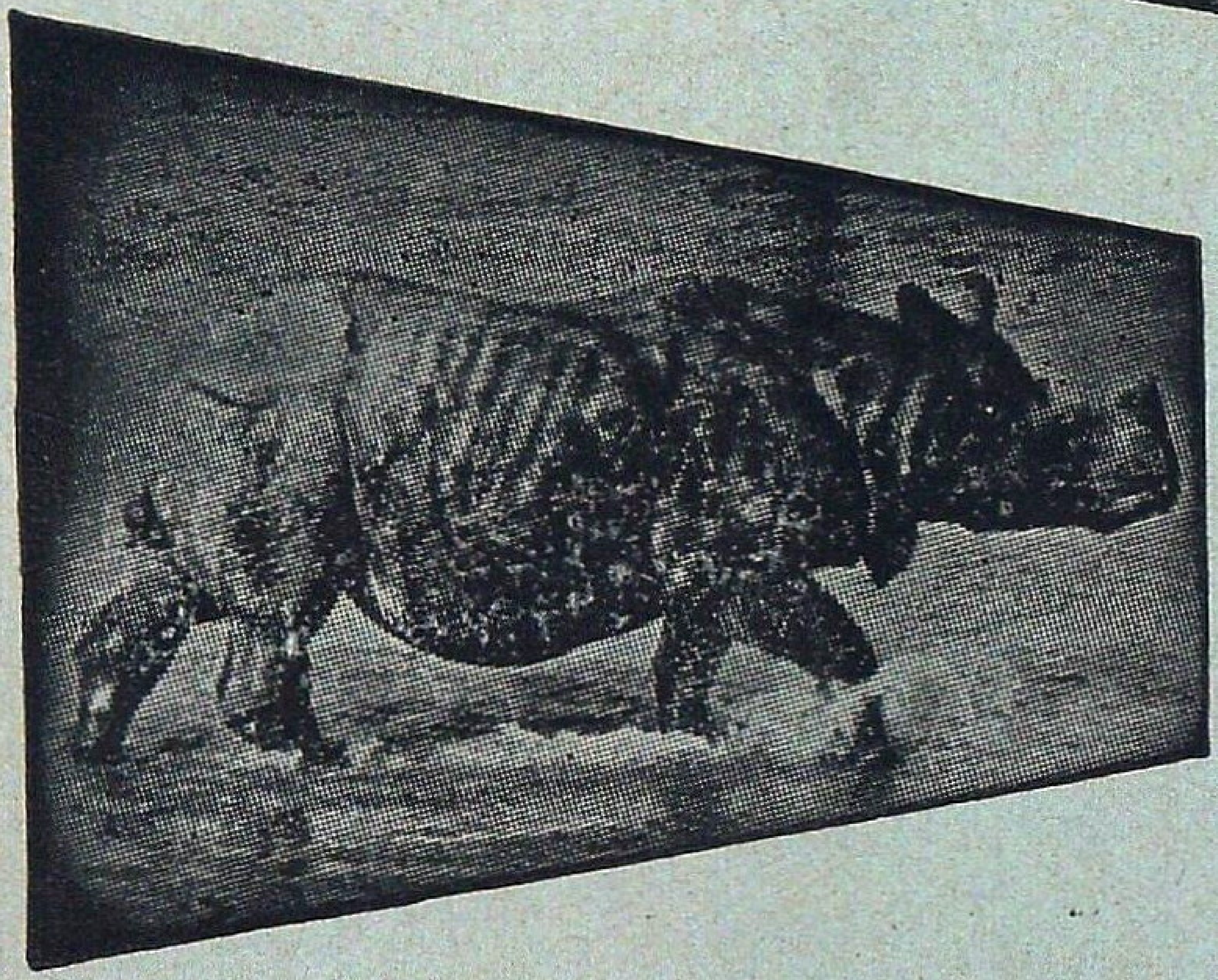

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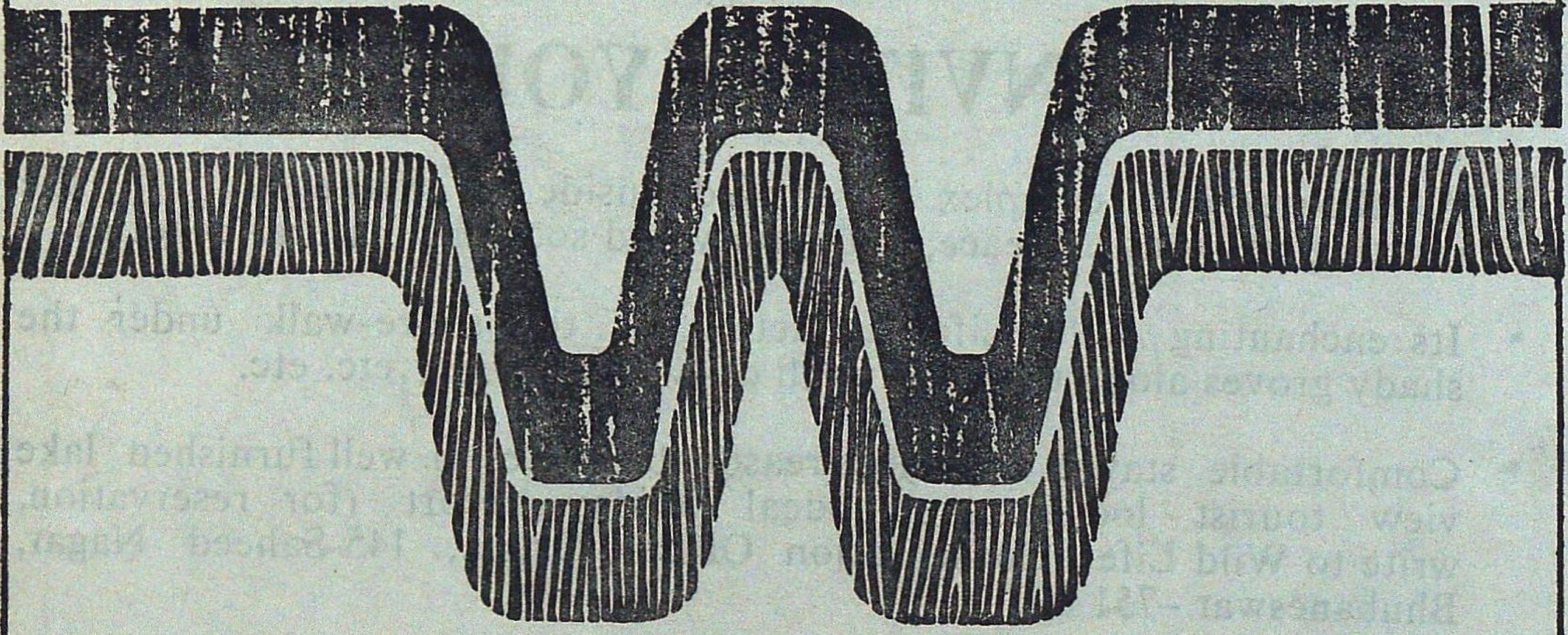

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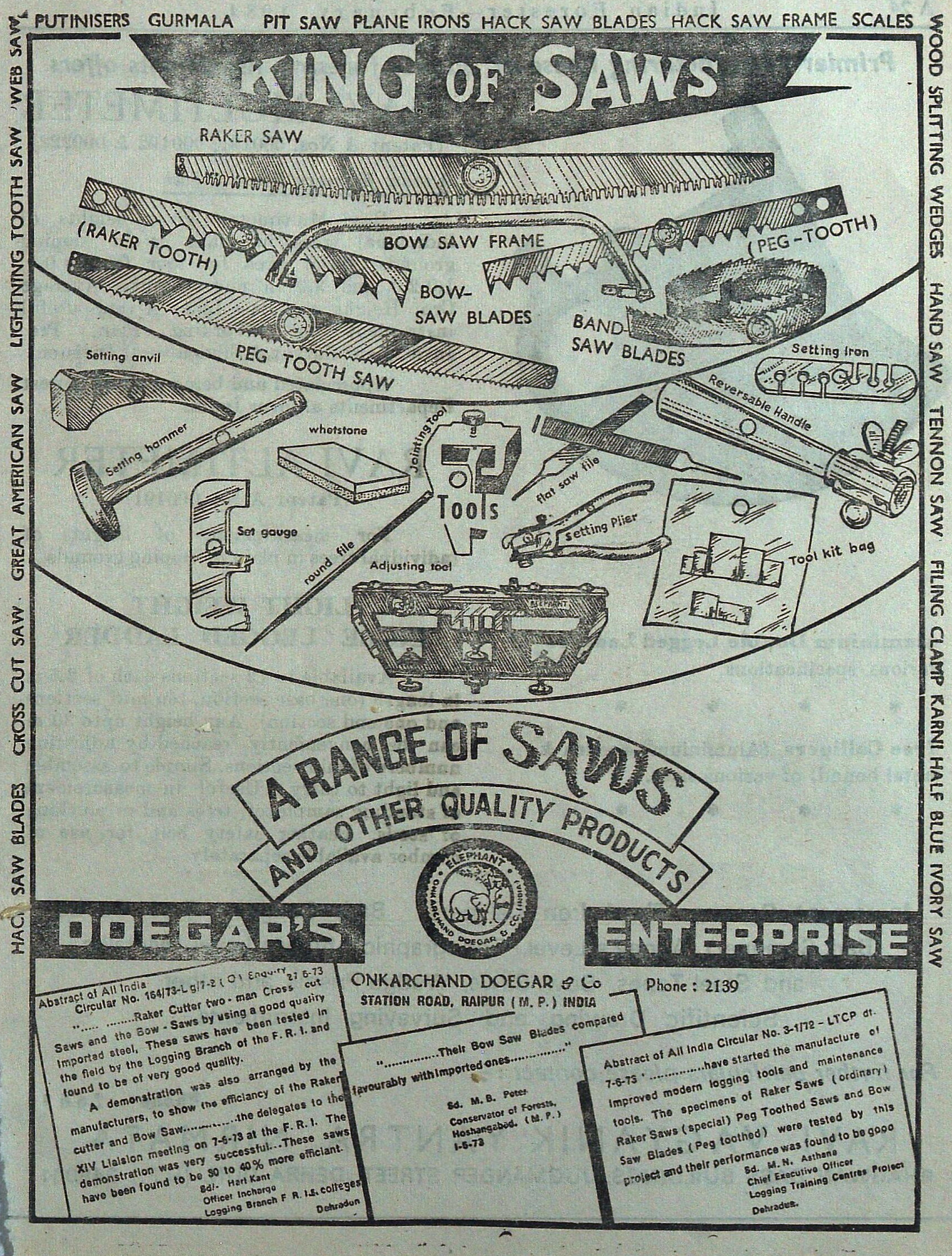

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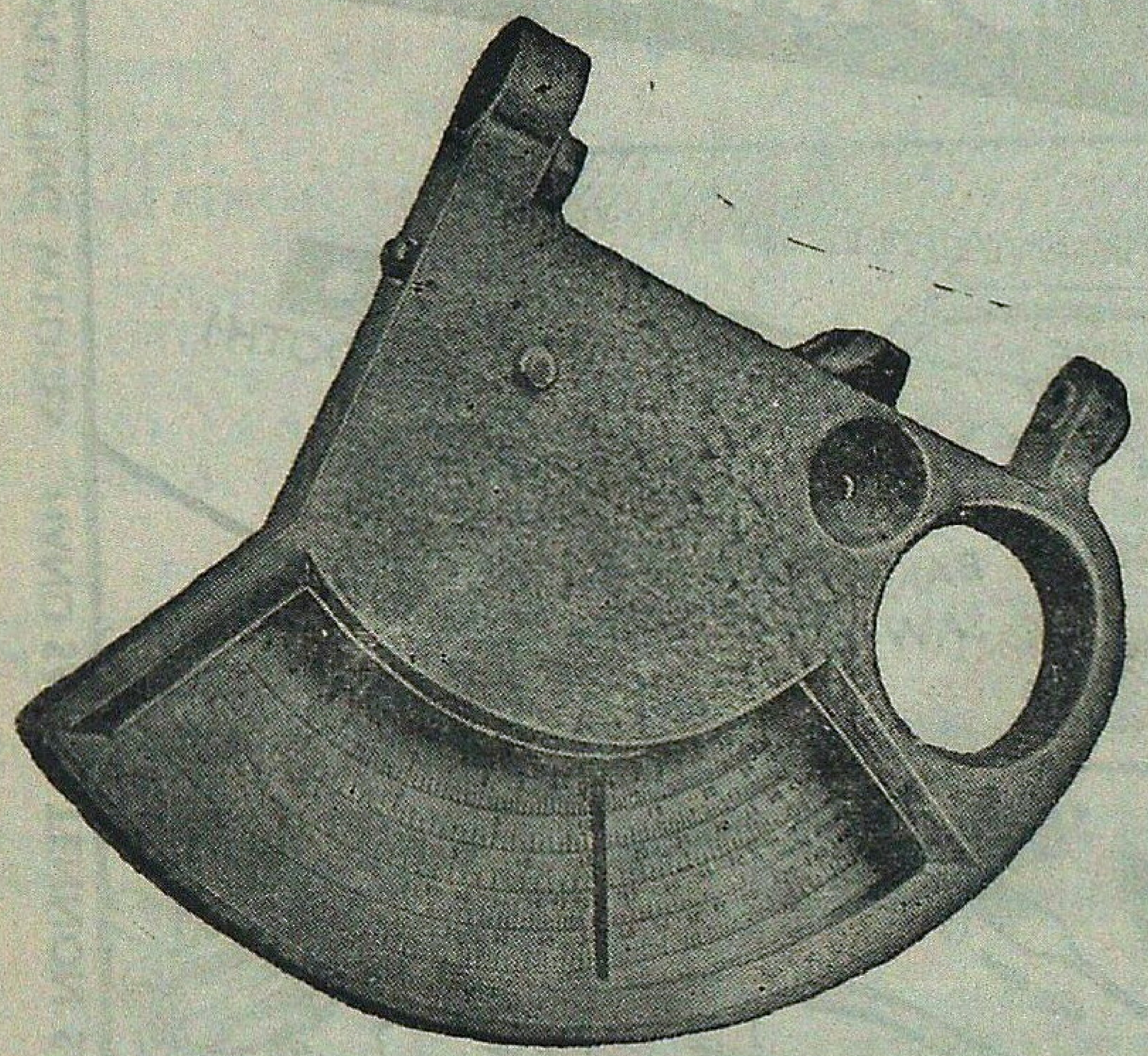

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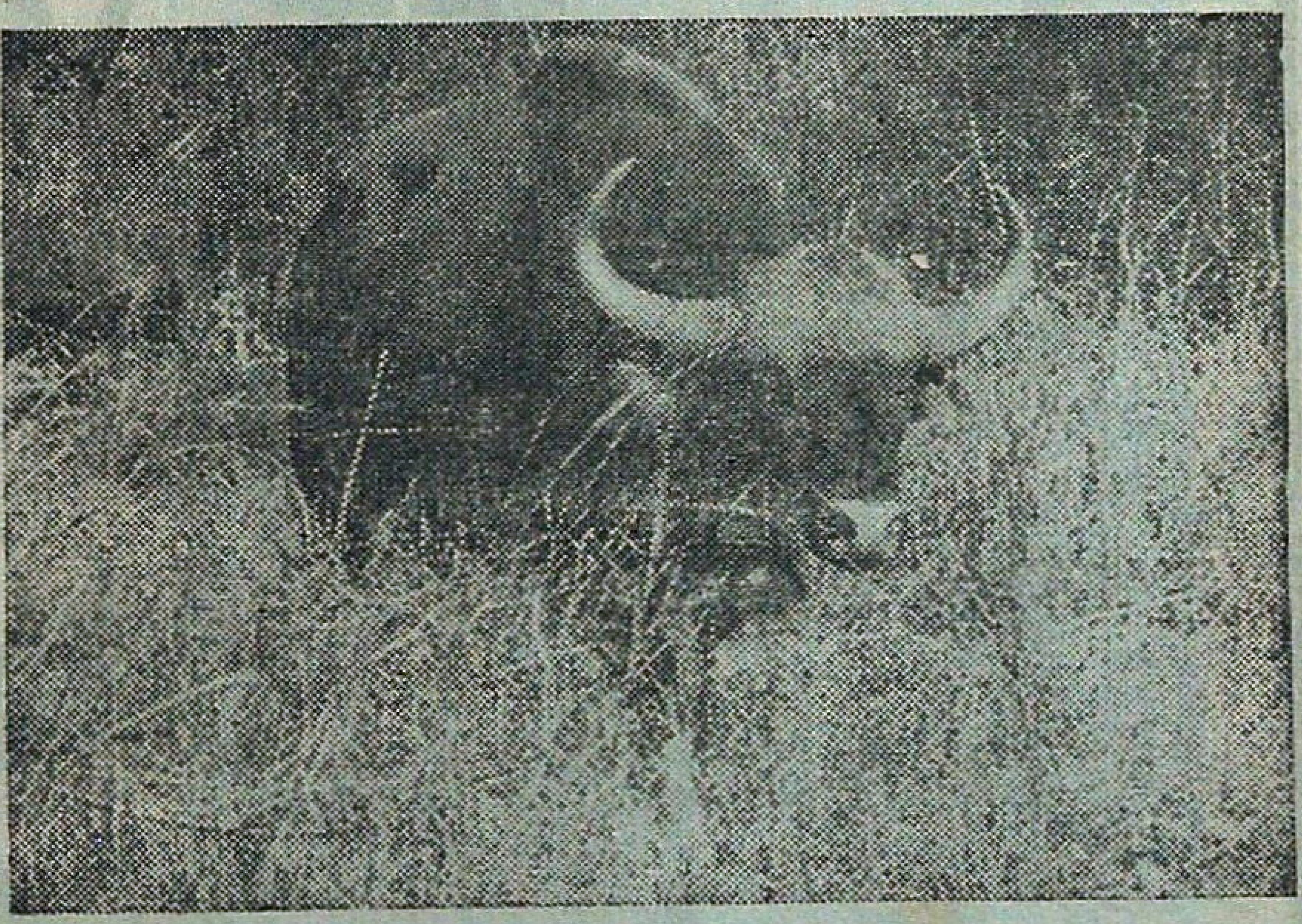

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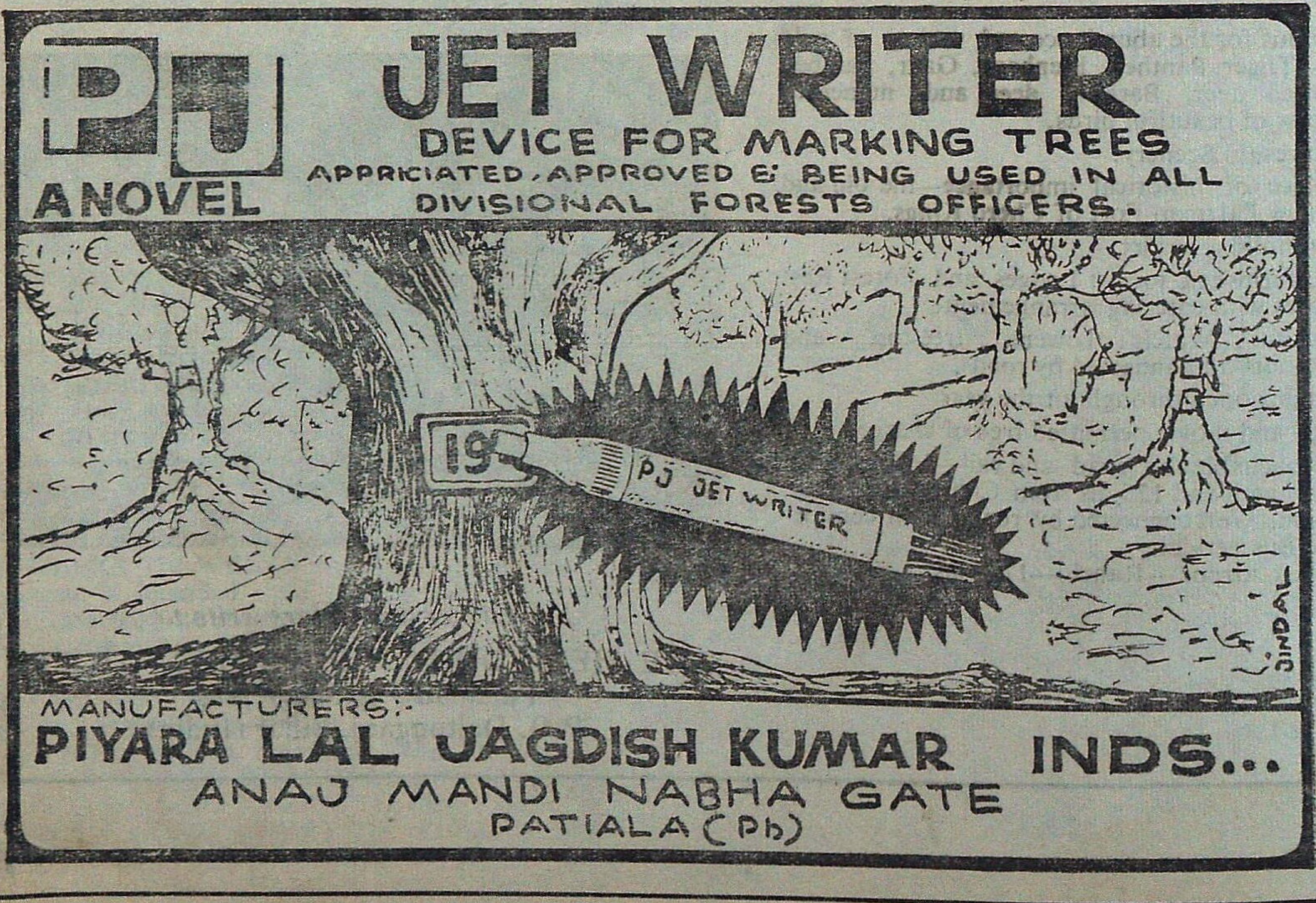

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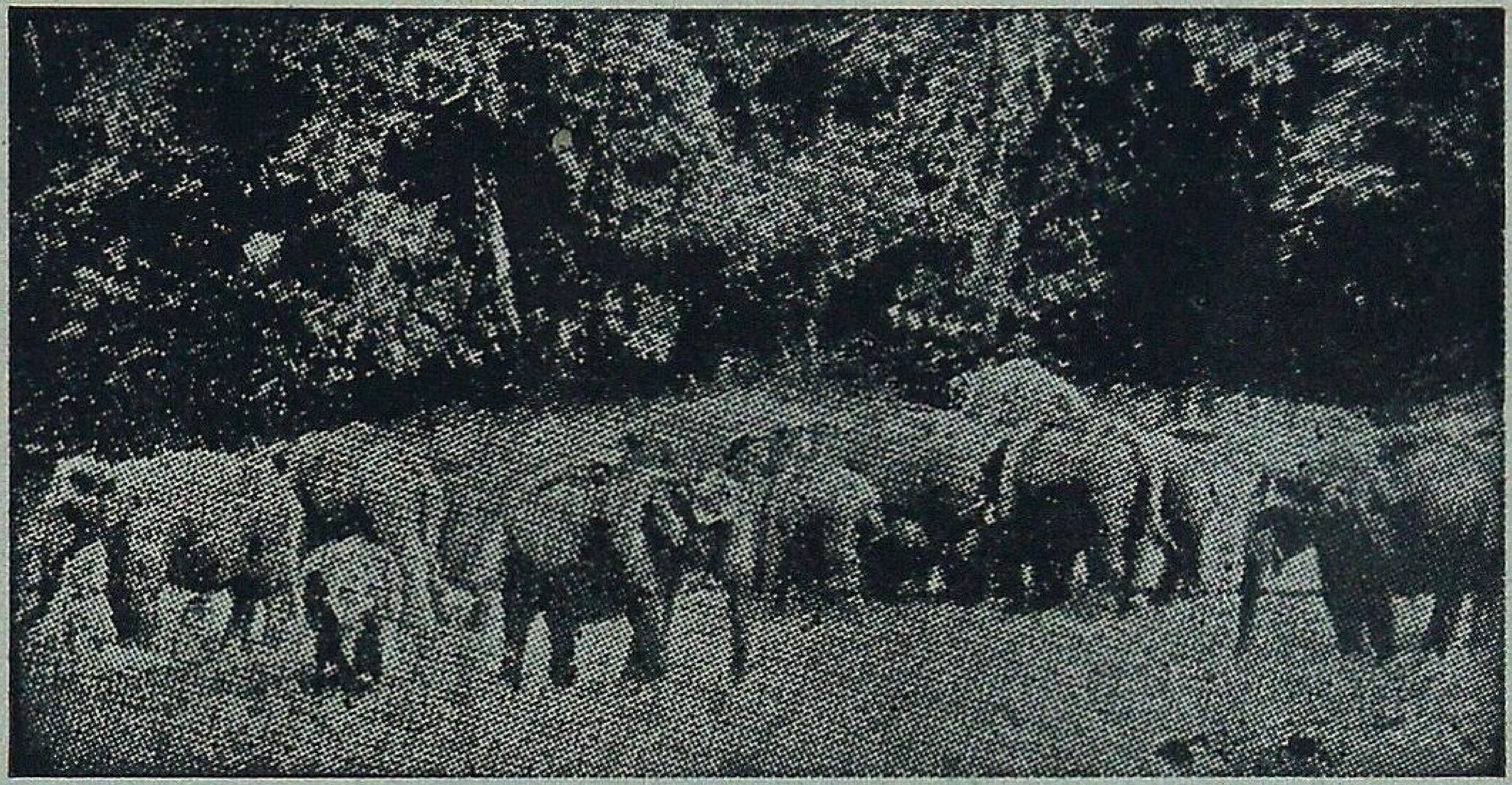

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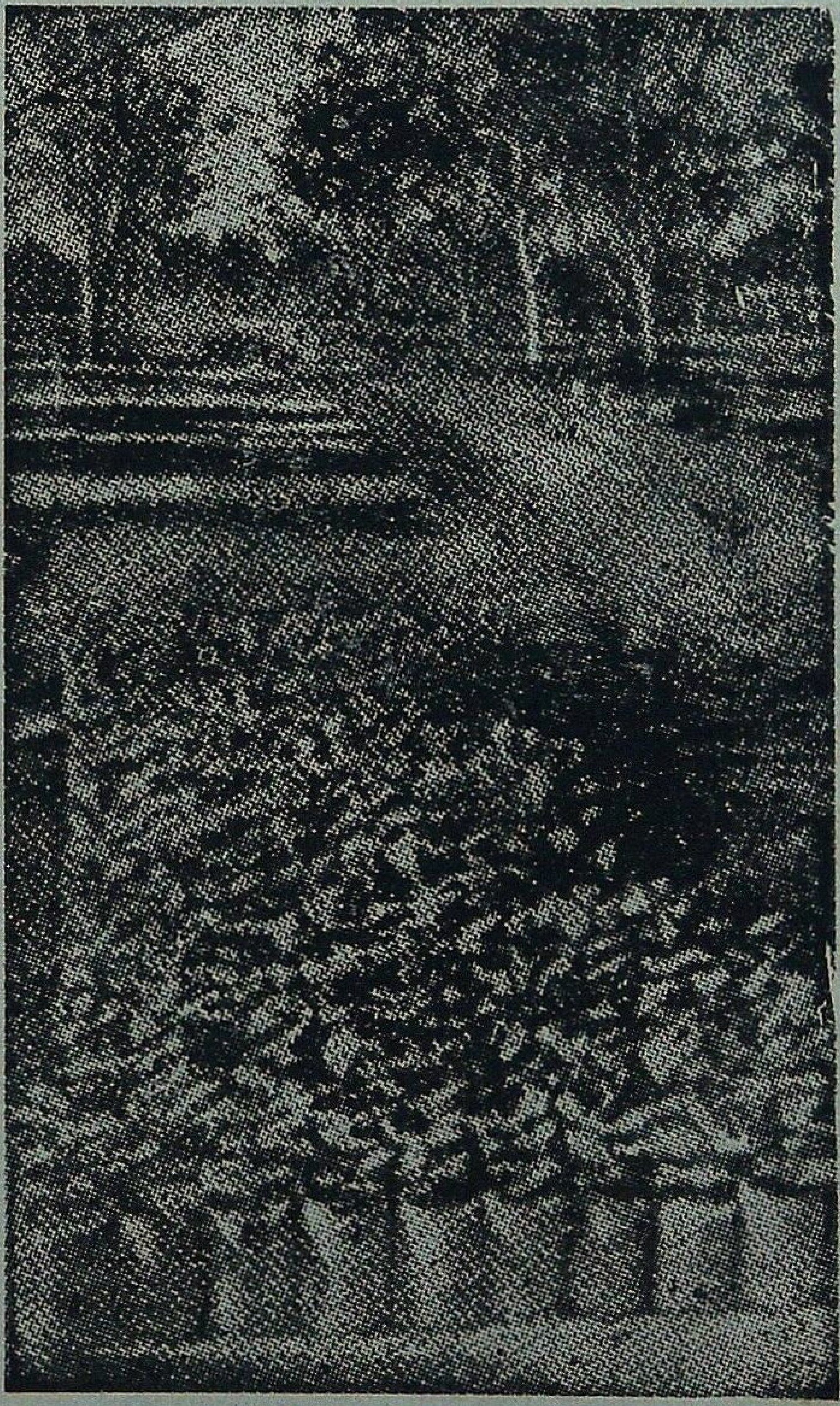

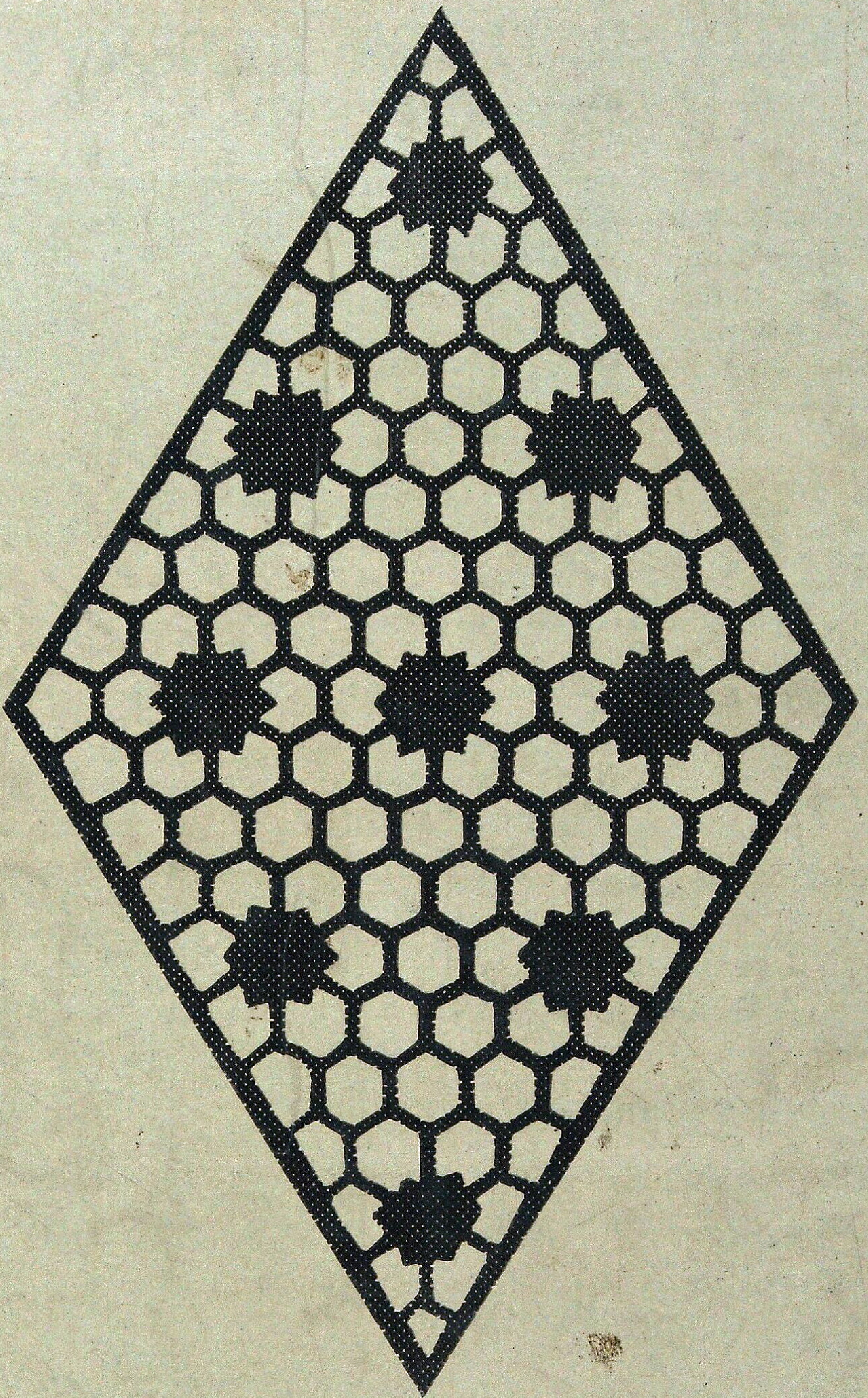

Edited by R.S. Mathur, I.F.S., Honorary Editor, Indian Forester (Director, Forestry Research, Forest Research Institute & Colleges, Dehra Dun), Published by N.K. Mathur, I.F.S., Business Manager, Indian Forester (Officer-in-Charge, Central Documentation & Library Branch, Forest Research Institute & Colleges, Dehra Dun) and Printed by S.K. Arora at Print World, Dehra Dun

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